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# Observations on the Algal Genera Acicularia and Acetabulum

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(WITH PLATES 24 AND 25)

## I. ACICULARIA SCHENCKII (Möb.) Solms

1. **Historical.**—The material from which *Acicularia Schenckii* was originally described came from Cabo Frio, Province of Rio de Janeiro, Brazil, where it was collected by Professor H. Schenck in May, 1887. It was first made known under the name *Acetabularia Schenckii* by Dr. M. Möbius in Hedwigia for 1889 (**28**: 318–320. *pl. 10. f. 8–12*). But in this species the aplanospores surround themselves each with a thick calcareous shell and these shells adhere, so that the aplanospores, by the decay of the sporangium wall, are left in a single coherent mass, retaining more or less the form of the sporangium; and on this ground, Graf zu Solms-Laubach in his Monograph of the Acetabularieae, published in 1895,* refers the species to the genus *Acicularia*, previously recognized only in the fossil state. The genus *Acicularia* was founded in 1843 by the French paleontologist d'Archiac,† the original species being *Acicularia Pavantina* from the Middle Eocene at "Pisseloup près Pavant." It was referred to the animal kingdom by d'Archiac, and this opinion as to its nature was generally held until

* Trans. Linn. Soc. Bot. II. **5**: 1–39. *pl. 1–4.*

† d' Archiac. Description géologique du Département de l'Aisne. Mém. de la Soc. géol. de France, $5^2$: 386. *pl. 25. f. 8.* 1843.

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1877, when Munier-Chalmas * placed it among the Algae next to *Acetabulum*. This idea Count Solms considers to be confirmed in a brilliant fashion by the discovery of a living species the spores of which are surrounded with lime and are coherent in masses strongly resembling the fossil "spiculae" on which alone the genus *Acicularia* was established. The description and figures given by d'Archiac of his "*polypier aciculaire*" deal only with its external characters, and if the more detailed account of *Acicularia Pavantina* given by Reuss † in 1861 can be depended upon, the affinities of this organism would seem to be still open to question, for the cavities supposed by Munier-Chalmas and Solms-Laubach to have been occupied by the aplanospores would appear from Reuss's figures to be somewhat narrowly and irregularly conical with the point directed inward. And in writing of the mouths or openings which are seen on the surface of the spicula, Reuss states, "Sie führen in nicht sehr tiefe Zellen, die in ihrer ganzen Weite ausmünden. Jede derselben ist, wie bei den Eschariden und Celleporiden, mit jeder der nebenliegenden durch einen feinen kurzen Canal verbunden." Count Solms ‡ remarks that he saw only one complete spicula of *Acicularia Pavantina* and is not able to express an opinion as to the internal form of the cavities. We have made several efforts to locate the type material of *Acicularia Pavantina*, with the hope of being able to see it and of being thus in a better position to hold an opinion as to whether the original *Acicularia Pavantina* and the *Acicularia Schenckii* are really congeneric, but our attempts thus far have been unsuccessful. § That the more recently described fossils, *Acicularia miocaenica* Reuss and *Acicularia Andrussowii* Solms, are closely allied to the living *A. Schenckii* would seem from published descriptions and figures to be very clear. The calcareous coating of the spore-walls and

* Observations sur les Algues calcaires appartenant au groupe des Siphonées verticillées (Dasycladées Harv.) et confondues avec les Foraminifères. Comptes-rendus de l'Acad. **85**: 814–817. 28 O. 1877.

† Reuss, A. E. Ueber die fossile Gattung *Acicularia* d'Arch. Sitzungsberichte der k. Akad. Wiss. **43**[1]: 7–10. *pl.* 1861.

‡ Trans. Linn. Soc. Bot. II. **5**: 35. 1895.

§ An intimation as to the whereabouts of the d'Archiac collection comes to hand when the publication of this paper is so far advanced as to render further delay inadvisable.

the cohesion in a single mass are the only characters separating *Acicularia*, as defined by Solms-Laubach, from the genus *Acetabulum*, and while a segregation on this ground is doubtless defensible, the propriety of thus using the generic name *Acicularia* perhaps awaits the further study of the fossil remains on which the genus *Acicularia* was founded.

The specimens on which the following observations were made were collected by the writer at Hungry Bay, Bermuda, on June 25, 1900. The plants were growing on small stones at about the low tide mark in a shallow creek leading out from a mangrove thicket. Through the kindness of Professors Möbius and Schenck we have been permitted to see the original Brazilian material of *Acicularia Schenckii*. A careful comparison of this and the Bermudian specimens reveals a few slight differences which are not, we believe, of specific significance. The differences are referred to below. Count Solms states that Goebel collected beautiful specimens of this species in Curaçoa and that it has been collected also in Martinique and Guadaloupe. But its occurrence now in Bermuda, about a thousand miles farther north, is in itself a point of some little interest.

2. **Descriptive.**

ACICULARIA SCHENCKII (Möb.) Solms, Trans. Linn. Soc. Bot. II. **5**: 33. *pl. 3. f. 9, 11, 12, 14, 15.* 1895.

*Acetabularia Schenckii* Möb. Hedwigia, **28**: 318–320. *pl. 10. f. 8–12.* 1889.

Green at first, becoming strongly calcified and chalky white with age : disc very nearly flat, solitary, 4–6 mm. in diameter, the margin crenulate ; sporangia 30–42, cuneate, strict, firmly connate at maturity except as to the rounded-obtuse minutely mucronate apex, the free extremities conical when young ; coronal processes mutually free, emarginate or emarginate-bilobed, with or without a transverse invagination, each bearing two caducous polytomous branches or the rudiments or scars thereof ; hypopeltal processes emarginate-bilobed, sometimes twice dichotomous : aplanospores 100–200 in a sporangium, globose, 66–84 $\mu$ in diameter ; the calcareous massula subcuneate, rounded or somewhat truncate at the distal extremity, exposing the imbedded aplanospores over its entire surface, usually thicker in the vertical plane than in the horizontal (tangential), the radial sides often concave toward the

enlarged outer end: rhizoids often irregularly inflated and filled with densely granular reserve-food materials: stipe 1–2.5 cm. (mostly 1.5 cm.) long, .28–.48 mm. in thickness: primary sterile branches 8–18 in a whorl (commonly solitary), finally 4 times (rarely 5 times) polytomous, the ramuli usually in 4's, the ultimate often in 3's or 2's.

The membranes throughout are thinner in the Bermudian plants than in the Brazilian, though susceptible to some variation in both. The wall in the apical region of the mature sporangium is in the former mostly about 9 $\mu$ in thickness while in the latter it ranges from 12 $\mu$ to 24 $\mu$ (measured after decalcification in both). But in only one sporangium, out of many examined, of the specimens collected by Dr. Schenck, have we seen the membrane relatively so thick as is indicated in Möbius' figure 12 (Hedwigia, **28**: *pl. 10.* 1889). Again, the coronal processes in the Bermudian plant are less emarginate or lobed and the hypopeltal processes less often show a tendency to become twice dichotomous, but these characters are extremely variable in both.

Professor Schenck writes that his specimens also were collected in a mangrove formation.

Apart from the other important differences, *Acicularia Schenckii* is very distinct from *Acetabulum crenulatum* (Lamx.) Kuntze in general habit and appearance, differing at first sight in being much smaller in all its parts and in the nearly flat discs.

By using some care, the contents of a mature sporangium can be removed in a single coherent conico-prismatic or subcuneate mass (Figs. 37 and 38), as happens in nature by the decay of the sporangium wall. By reflected light, under low magnification, one of these bodies appears white, with the light green aplanospores occupying slight depressions or pits on the surface, but higher magnification shows that the pitted appearance is largely an optical illusion; for unless the aplanospores have collapsed in the process of preservation — which sometimes happens even in formalin material—their outer surface is on about the same level with the surrounding matrix. It is a point of some biological interest that the side of the aplanospore which lies toward the surface of the massula is always the one which bears the lid, and in the lid region, so far as we have observed, is always free from the

calcareous incrustation; and every spore seems to have a surface exposure. When the massula, viewed from above, appears unusually broad, it can be shown to be hollow toward the larger end. In most cases, however, it is solid, except for the small interstices, and toward the larger extremity is concave at the sides (Figs. 37 and 38), so that a vertical transverse section has somewhat the form of a biconcave lens. This arrangement, whereby each aplanospore has its lid-bearing surface exposed and uncalcified, is an interesting adaptive feature which seems to have escaped formal recognition hitherto. Count Solms-Laubach in figuring * a portion of the surface of a massula does not fail to indicate that the lids of some of the spores are visible, but in describing the "lime-spicula" (our *massula*) he writes † as follows: "It consists of a strongly calcified substance enclosing numerous cavities lying near the surface, and consequently transparent. In each of these and completely filling it there is a spore of the same structure as those of *Acetabularia*. It follows that the pits of the fossil forms are the spore-containing cavities from which the spores have disappeared and the external lime-covering has not been preserved, so that they appear as opening outwards."

In the Bermudian specimens, and in the Brazilian so far as we have seen them, the spore-cavities not only lie "near" the surface but actually reach the surface and for a region approximately corresponding to the spore-lid there is no "external lime-covering" to disappear; and the cavities not only "appear as opening outwards," but such is actually the case from the beginning. This is shown in an especially striking fashion when massulae from formalin-preserved material are allowed to dry on a glass slide and are observed under comparatively low magnification with reflected light. The spores in shrinking away from the surface leave actual openings. It can be determined more accurately by use of high powers and transmitted light that the lid is either wholly free from the calcareous coating or is at most but partially covered with an unimportant amount of it.

By transmitted light, the matrix is yellowish, minutely granular, and somewhat waxy in appearance. As has already been

* *l. c., pl. 3. f. 9.*

† *l. c.* 10.

remarked by Solms-Laubach, the calcareous matter seems to envelop each spore separately like a shell, with a definite though commonly irregular boundary, and the massula (spicula) is apparently formed by the cohesion of these shells. Empty interstices, triangular or varied in form, are often to be seen among adjacent shells. Solms-Laubach inclines to the view that a sort of slime is formed from the outer surface of the spore-wall and that the lime is deposited in this, a cuticle being afterwards reformed inside the shell of lime. An alternative supposition, namely, that the lime is first deposited in a residual substance left in the sporangium after the formation of the spores, seemed to him less probable on account of the peculiar distribution of the lime. With the hope of throwing a little more light on this point, we have made an effort to see the spores in the earlier stages of development, using both dry material and that preserved in formalin. We are confident that in the great majority of cases, at least, the lime first appears as a very delicate coating on the outer surface of the spore-wall and that this coating gradually increases in thickness. The presence of a coating of slime or mucilage could not be demonstrated with certainty at any stage, though the ordinary mucilage tests were employed. Nevertheless, certain optical appearances give ground for the suspicion that something of the kind is present. The few cases in which the lime seemed to make its first appearance in a possible residual matter of the sporangium could be attributed to a disturbance of the natural relations in manipulating the specimen. The sporangium walls are more or less calcified and opaque when the formation of the spores begins and it therefore becomes necessary to remove or decalcify the walls before a clear view of the contents can be obtained, but decalcification is naturally out of the question when the mode of origin of the calcareous shells of the spores is the point under investigation.

3. **Developmental.**—It was noted by Strasburger* in 1877 that *Acetabulum Androsace* (Pallas) Kuntze [*Acetabularia Mediterranea* Lamx.] has a perennial basal portion consisting of rhizoids densely filled with reserve food materials. Similar rhizoidal reservoirs which apparently persist are now found in *Acicularia Schenckii* (Fig. 1).

* Bot. Zeit. **35**: 715–718. 1877.

As has already been described for *Acetabulum Androsace* and *A. crenulatum*, the young shoot in *Acicularia Schenckii* is an erect cylindrical or often somewhat curved tube, with a tapering subacute or rounded apex. In two cases out of the many young plants examined, we have observed the beginnings of a dichotomous branching (Fig. 22); in all other cases the shoots have been simple. The development of the primary whorls of articulated sterile branches offers no peculiarities worthy of special mention except the fact that we have been unable to find more than one whorl of such branches persisting at any one time. Harvey* figures in the young plant of *Acetabulum crenulatum* previous to the formation of the fertile disc three whorls of sterile branches and the beginning of a fourth and Woronin † gives a similar figure for *Acetabulum Androsace*. In *Acicularia Schenckii* two or three whorls are sometimes developed in succession before the formation of the disc, but in such the lower whorl has fallen by the time the next higher appears, and only scars remain to testify to its former existence. We have found no conclusive evidence that a plant of *A. Schenckii* ever matures more than one fertile disc. One case has been met with, in which a single shoot bore the beginnings of two discs separated by the scars of a whorl of sterile filaments, but in this the lower of the two rudiments showed unmistakable indications of arrested development in small size, unequal growth, and occasionally exfoliated members, and the suspicion that it was destined to no further growth seems well grounded. A case in which the development of a disc seems similarly arrested and the continuation of the axis shows the beginnings of a sterile whorl is represented in Fig. 20. Fig. 21 shows the scars of a delapsed disc and the prolification of the axis, but there is no proof that the delapsed disc reached maturely or that, if it did, another disc would actually reach the spore-bearing stage. Yet it must be admitted that cases like those just described suggest the possibility that a plant may occasionally mature two discs.

With the aid of material preserved in formalin, we have been able to follow out stages in the development of the disc which have been observed hitherto only in *Acetabulum Androsace* and

* Ner. Bor.-Am. 3 : *pl. 42.* 1858.

† Ann. Sci. Nat. Bot. IV. 16 : *pl. 8.* 1862.

more completely in some respects than is indicated in the recorded observations on that species. This practically complete series of early stages in the development of the disc seems to confirm, with much certainty, the morphological explanation of the disc put forward by Count Solms-Laubach in 1895, and perhaps justifies carrying his idea a little further. The disc begins as a whorl of ovoid protuberances, which are at first free from each other, though in close juxtaposition. A little later, these processes become oblong-cylindrical or somewhat tongue-shaped in outline (Figs. 6–8). The formation of the partial partition constituting the distal boundary of the vestibule at the base of each process begins very early (Figs. 6 and 7). In fact it seems to be formed almost simultaneously with the process itself, for we have been able to find no stage so young as to show no trace of it. The next step is the appearance of the rudiments of the two articulated sterile branches (Fig. 8), which begin as dome-shaped protuberances at the apex of the process. It is of interest that these protuberances commonly do not at first stand one in front of the other or in line with the radius of the disc, as they usually seem to do at a later time, but are almost side by side in line with a tangent to the disc. And when, as rarely happens, three rudiments of sterile branches appear instead of two, the three are never in a straight line but form an evident terminal verticil. The later development commonly thrusts them nearly into a radial line, but there are some exceptions to this as will be seen from our Fig. 30. In the course of time, each of these outgrowths becomes strongly constricted in the zone of emergence from the body of the original process and is at length in communication with it only by a narrow slit which is bounded by a callus-like thickening of the membrane. And this narrow slit is evidently closed in the scars which remain after the fall of the sterile filaments. Closely following the appearance of the rudiments of the sterile branches, the first indication of the origin of the sporangium may be recognized. The sporangium begins as a rather broad out-pocketing on the outer face of the original process at about its middle or sometimes nearly as low as the basal third (exclusive of vestibule). It is from the first broader than the rudiments of the sterile branches and though it becomes somewhat constricted at its base

this constriction is not so pronounced as in the case of the sterile branches. The young sporangia are at first abundantly free from each other. They are at an early stage short-cylindrical or somewhat club-shaped, with a rounded-obtuse apex (Figs. 12, 13, 15), but a little later, when they come to be coherent laterally, each has a free apex that is decidedly conical or conico-mammillate (Fig. 19). While, however, the disc is still very small, the end of the sporangium broadens out and nothing but a small mucro remains to represent the conical apex of the earlier stage, and even this mucro is sometimes obscure or obsolete. The hypopeltal process (segment of the *corona inferior* of Solms-Laubach) originates a little later than the sporangium. It begins as a broad dome-shaped outgrowth involving the whole region between the base of the sporangium and the vestibule-wall. Its further development offers nothing worthy of special comment unless it be the fact that it becomes strongly emarginate or emarginate-bilobed. That the hypopeltal process bears neither polytomous filaments nor the rudiments of them is well understood. It has already been noted that the rudiments of the polytomous filaments at the time of their emergence from the previously undifferentiated primordial ray are terminal in position. Later, however, the region just below them on the side toward the sporangium grows out into what is finally the emarginate or emarginate-bilobed apex of the coronal process. In reality, the organic apex of the ray as a whole is doubtless still to be found somewhere between the points of insertion of the two polytomous branches or their rudiments, having been thrust into an apparently lateral position by the development of the three superposed lateral outgrowths, namely, the sporangium, the hypopeltal process, and the terminal portion of the coronal process. The developmental history of the ray thus forces us to accept in the main the views of Solms-Laubach in regard to the morphological homologies of the disc and its parts, as opposed to the views of Falkenberg,* Cramer,† and Wille.‡ *The whole disc or cap* (including sporangia, coronal and

* Falkenberg, P. Schenck, Handbuch der Botanik, **2**: 270. 1882.

† Cramer, C. Denkschr. Schweiz. natf. Gesellsch. Zurich, **30**:—(35). 1887.

‡ Wille, N. Engler & Prantl, Die natürlichen Pflanzenfamilien, $1^2$: 152–159. 1890.

hypopeltal processes, polytomous disc-filaments, etc.) *evidently is not a complicated aggregation of whorls of primary branches and the sporangia are, with little doubt, not to be compared with the ordinary verticillate branches or branchlets.* As Solms-Laubach has maintained, the sporangia in the Acetabuleae are most naturally to be compared with those of *Bornetella*, in which genus the sporangia arise laterally and irregularly from the primary whorled branches (*i. e.*, from the branches of the "first generation") and have no evident homologies with the verticillate sterile branches. It may be remarked that, according to Cramer, the sporangia in *Bornetella nitida* (Harv.) Mun.-Chal. occur singly on the branches of the first order, while in *B. capitata* (Harv.) J. G. Ag., they are more numerous, ranging from 9 to 35 for a single branch. Now in view of the fact that in the Acetabuleae (if our observations on *Acicularia Schenckii* and *Acetabulum crenulatum* * may be considered typical for the group) the hypopeltal process and the distal portion of the coronal process are lateral outgrowths like the sporangium, we are of the opinion that these structures are best looked upon as abortive sporangia. The logical result of this comparison of the ontogeny of the ray with the relation of parts in *Bornetella* is the conclusion that *the whole cap, with all its radially arranged parts except the vestibules, corresponds to a single primary whorl of branches.* The original outgrowth which gives rise to the terminal rudiments and to the lateral sporangia is the branch of the first order (*i. e.*, corresponds to the first segment of the ordinary primary branch), whence it follows that the sterile polytomous filaments which may arise from it later are branches of the second order. The *velum partiale*, as it might be called, which separates the base of the ray (the chamber of Cramer's "Zwischenstück") from the vestibule (Figs. 33 and 34) is evidently homologous with the constriction which separates the base of the primary sterile branch from the main axis of the plant. It is here that the ray detaches itself when the cap finally falls—though the fertile sporangia alone are often first detached. In this connection, it is of interest to note that the primary sterile branches show at their beginning distinctly recognizable basal cushions corresponding to

* See page 331.

vestibules, though these afterward become obscure. It may be remarked, too, whether significant or not, that the vestibule communicates with the base of the ray by an elongated slit (Fig. 35) lying transverse to the main axis of the plant and that the passageway at the base of the primary sterile branch just previous to its final closure is a similar slit also transverse to the main axis of the plant (see scars in Figs. 5 and 6).

### II. ACETABULUM CRENULATUM (Lamx.) Kuntze

*Acetabulum crenulatum*, like *Acetabulum Androsace*, as described by Strasburger,* and *Acicularia Schenckii*, as described above, has more or less enlarged rhizoids densely filled with a finely granular material which presumably serves as a reserve food supply. The mode of development of the disc and its parts is essentially as is described above for *Acicularia Schenckii*. As in that plant, one very rarely finds incipient rays which bear rudiments of three polytomous filaments instead of two and these are always equidistant in a terminal whorl. One such case is represented in our Fig. 17. It would be of interest if those who have access to the growing *Acetabulum Androsace* with its more numerous coronal "hairs" or hair-rudiments would determine whether or not these 4–7 outgrowths orginate in a perfect verticil. We are familiar only with the figures of Solms-Laubach bearing upon this point. His figure 4 (*l. c., pl. 1*) indicates the possibility of such an arrangement, but his Fig. 7, in which the sporangium is still in a very young stage shows the rudiments of the sterile branches in a straight radial row. From analogy with *Acicularia Schenckii* and *Acetabulum crenulatum* and from the relations of these parts as described by Solms for the matured *Acetabulum polyphysoides* and *Acetabulum Möbii*,† it is to be expected that the coronal "hairs" of each ray in *Acetabulum Androsace* also will be found to exhibit a terminal verticillate arrangement at the time of their origin.

### III. ACETABULUM CARAIBICUM (Kütz.) Kuntze

*Acetabulum Caraibicum*, ‡ in our opinion, cannot be satisfactorily distinguished from *A. crenulatum*. Through the courtesy of

* Bot. Zeit. **35**: 715–718. 1877.

† *Acetabularia Möbii* Solms, Trans. Linn. Soc. Bot. II. $5^1$: 30. *pl. 4. f. 1.* 1895.

‡ *Acetabularia Caraibica* Kützing, Tab. Phyc. **6**: 33. *pl. 93.* 1856.

Mme. Weber-van Bosse, we have been able to see four of the six individual plants, by which, she writes, the evident type of the species is represented in the Kützing herbarium.

Graf zu Solms-Laubach, though admitting the close relationship of *Acetabulum crenulatum* and *A. Caraibicum*, attempts the following distinctions in his key * to the species of the genus:

"Disci infundibuliformes saepius plures superpositi, radiis apiculo convexo." *A. crenulatum*

"Discus planus, radiis apice emarginatis, apiculum parvum gerentibus." *A. Caraibicum.*

The alleged difference in the form of the disc appears not to be borne out either by Kützing's original figures or by the specimens preserved in his herbarium. In all the latter, so far as we have seen them, with one exception, the disc is as strikingly infundibuliform as in any condition of *A. crenulatum*; and this one exception, if it may be so called, is a disc which has been artificially flattened on a piece of mica and evidently decalcified. Moreover, the discs are sometimes superposed in pairs in *A. Caraibicum*, as shown in the original figures and in the specimens themselves. The plants with two discs were made by Kützing to constitute his variety *calyculata*, but they were apparently growing with the others and do not deserve a varietal name any more than the similar conditions which have long been recognized in *A. crenulatum*. In regard to the apiculum, there is little difference. In Kützing's plants it is very conspicuous when the sporangium is young, but becomes more or less obscure with age—as also is generally acknowledged to be sometimes the case in *A. crenulatum*. The apiculum is, however, discernible in each of the four Kützingian plants examined. The paucity of the original material forbade any extended observations on the form of the apex of the mature sporangium in the soaked-out condition, but we found none so strongly emarginate as figured by Kützing. The apices of the matured sporangia appear rather to be merely truncate or slightly retuse, more as figured by Count Solms (*l. c., pl. 1. f. 10*), and we think it must be admitted that a subtruncate sporangium-apex is quite normal in *A. crenulatum*. Solms-Laubach mentions also the "slightly calcified cap" as one of the characters by which *Acetabulum Caraibicum*

* *l. c.* 20.

may be generally distinguished, but it seems to us that this description cannot well be applied to the plants of Kützing.

By way of further description of Kützing's specimens, it may be remarked that the number of sporangia in a disc varies from 32 to 52, that the largest disc seen is 7 mm. in diameter, and that the emarginate coronal processes bear two "hair-scars" or two undeveloped rudiments. The pocket in the Kützing herbarium bears the inscription, "*Acetabularia caraibica* Lamx.," though why the name should be attributed to Lamouroux is not quite clear. Another specific name, with "Kg." after it, was first written, but was so effectually scribbled out that we were unable to decipher it. The pocket is numbered 103 and at the bottom is written "Von den Antillen. Koch."

## Explanation of Plates

PLATE 24

1–16 and 18–22. *Acicularia Schenckii* (Möb.) Solms.

17. From *Acetabulum crenulatum* (Lamx.) Kuntze.

1. Basal portion, showing rhizoidal food-reservoirs, × 28.

2. Apical portion of a young plant, × 16.

3. A later stage, showing beginnings of a primary whorl of sterile branches, × 55.

4. Apex of plant crowned with well-developed primary whorl of sterile polytomous branches, × 55.

5. Apex of plant at a little later stage; primary branches falling and main axis continuing its upward growth, × 55.

6. Apical portion of plant, showing beginning of a disc, × 55.

7. Three of the tooth-like processes constituting the young disc in Fig. 6, × 245, outer (distal) aspect.

8. Process from a slightly older cap-rudiment, distal aspect, × 245. At the apex (*a*) are seen the beginnings of what afterward will become the disc-filaments or the abortive rudiments of such.

9. The same a little more advanced, showing at *b* the first indication of the sporangium, × 245.

10. A similar process viewed laterally, × 245. The beginning of the sporangium at *b*.

11. A primary process from a more advanced stage of the disc, in lateral view, showing now at *c* the beginning of the hypopeltal process, × 245.

12–15. Similar and later stages from various young discs, lateral views, × 245.

16. A primary disc-forming process at a little later stage than the preceding, in distal view, × 245; *b*, the sporangium; *c*, the hypopeltal process. The true apex, with its two rudiments of disc-filaments, is hidden behind *b*.

17. A primary disc-forming process from *Acetabulum crenulatum*, showing rudiments of three disc-filaments in a terminal whorl, × 193.

18. Young disc of *Acicularia S henckii*, seen from above (slightly flattened under cover-slip), × 18. At this stage, with the present magnification, scarcely anything more than the conspicuously pointed young sporangia is visible.

19. Terminal portions of young sporangia from the preceding, × 40.

20. Prolification of axis, × 16. At about the lower third are scars left by the fall of a whorl of primary sterile branches; above this an apparently abortive disc-rudiment; at the apex, the beginnings of another whorl of primary sterile branches.

21. Prolification after the fall of a disc, × 16.

22. Prolification and dichotomy, × 16.

PLATE 25. *Acicularia Schenckii* (Möb.) Solms.

23. Plants with mature discs, natural size.

24. A mature disc viewed from above, × 7.

25. Apex of mature sporangium, surface view, showing the small terminal apiculum, × 40.

26. Another sporangium-apex in optical section after decalcification, × 40.

27. Coronal processes, × 55.

28. Coronal process, with two scars left by the fall of disc-filaments, × 245.

29. Coronal process with transverse invagination, one disc-filament-scar, and one abortive rudiment of a disc-filament, × 245.

30. Coronal process with transverse invagination, after decalcifying, × 245.

31. Hypopeltal processes, × 55.

32. A single hypopeltal process, with vestibule below, × 245.

33 and 34. Slightly diagrammatic radial sections, showing relations of the various parts of the disc, × 180. *a*, the disc-filaments or their rudiments; *b*, the sporangium; *c*, the hypopeltal process; the dotted line marks the inner lateral boundary of the vestibule. In Fig. 33 the coronal process shows a transverse invagination.

35. Vestibules viewed from the main axial cavity of the plant, × 245. In each, the passage-way leading into the coronal chamber is seen to be elongated transversely to the plant axis; the appearance of this passage-way in vertical section is shown in Figs. 33 and 34.

36. A single mature sporangium viewed from above, showing toward the apex the falling away of the sporangium wall and the resultant exposure of the aplanospores, × 16. Drawn from a glycerine mount. The aplanospores are as a rule less clearly visible through the sporangium wall, even in a glycerine mount, than the present figure would indicate.

37. A spore-mass (massula) removed from the sporangium entire, viewed from above or below (using these terms with reference to its former position in the disc), × 16.

38. The same massula in lateral view, × 16.

39. Portion of massula in surface view, × 55.

40. A single aplanospore with its calcareous incrustation, in optical section, × 193.

41. Aplanospore with calcareous coating fallen away, × 193.

42. Aplanospore, showing operculum, after treatment with strong acetic acid, × 245.

43. The operculum and adjacent portions of the aplanospore wall, in optical section, after treatment with strong acetic acid, × 750 (reduced from 1500).

COLUMBIA UNIVERSITY, May 16, 1901.

## The Work Performed in Transpiration and the Resistance of Stems

By Carlton C. Curtis

It is a matter of some difficulty to make a clear demonstration of the amount of work performed by a plant in transpiration. The usual method of measuring the extent of this important operation, *i. e.*, through the lifting power of the transpiration current, is open to objection, since the stem usually allows the air to infiltrate and stop the rise of the column of mercury long before the measure of the force of transpiration has been reached.

A nearer approach to the extent of this force may be attained by subjecting a given length of the stem to pressure and forcing water through it at a rate equalling that of the transpiration stream. This may be easily accomplished, after determining the rate of transpiration with a Darwin potometer, by removing the capillary tube from the potometer and attaching it with a short piece of rubber tubing, about 20 cm., to one end of the stem, while the other end of the stem is connected with a burette by means of a longer length of tubing, so as to allow wide latitude in the amount of pressure applied. The tubings are filled with water before attachment to the stem, and care must be exercised to exclude the entrance of any air, since the latter acts as an effectual block to the passage of water. These connections are effected under water with more ease and safety from introduction of air. For short lengths of stem an apparatus stand will give sufficient elevation to the burette to furnish the necessary pressure.

The burette and tubings having been properly attached, any water that passes though the stem escapes through the capillary tube. By pinching the tube connected with the capillary tube between the fingers, a given amount of water can be forced out and absorbed with a blotter, and with the removal of the pressure the water in the tube will be drawn back. With a few trials it is possible to judge accurately just how much water to force out in this way, so that the capillary tube will be left nearly empty upon releasing the pressure. The water passing through the stem will

cause the water to flow again through the tube, and the current may be timed over the same course as in the transpiration tests. The base of the capillary tube is attached to the rubber tubing in order that the same lapse of time may intervene before measuring the rate as is utilized in the measurements with the potometer. It is important that no more water than the volume of the capillary tube should be forced out, otherwise air will be drawn back into the rubber tube and introduce sooner or later troublesome Jamin's chains in the tests. While it is feasible to test only short lengths of stems by this method, the considerable resistance offered by such pieces gives a very striking and accurate basis for an estimate of the work performed in transpiration. The objection might be raised that in subjecting stems to pressure in this way histological elements would become active in the transmission of water that were functionless in transpiration. While it must be conceded that all cells may not be equally active or are quite functionless, in such stems as may be tested by a potometer, we are dealing with only a few annual zones of growth—frequently but one—and therefore no considerable error is encountered from this source. The demonstration by Strasburger that at least several annual zones assist in transpiration, as may also readily be observed in sections of stems that have imbibed colored solutions, renders it possible that under the pressures required for short sections of most woody plants the ordinary conducting cells are alone active in the transmission. In the case of some stems of high resistance, noticeably succulents, it is very obvious that a pressure that will force water through the stem at a rate equalling that of transpiration causes a considerable exudation from the extra-xylar tissues of the pith and cortex. In such cases, certainly, the action of these normally feebly transmitting cells would lower somewhat the resistance encountered by the passage of water through the xylem.

I.

| | 1 | 2 | 3 | 4 | | | 1 | 2 | 3 | 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Abutilon* | 48 | 45 | 49 | 10 × | .8 | *Acalypha* | 13 | 13 | 29.5 | 10 × | .5 |
| | 46 | 45 | | | | | 12 | 13 | | | |
| | 47 | 46 | | | | | 13 | 13.5 | | | |
| | 48 | 47 | | | | | 13 | 14.5 | | | |
| | 48 | 48 | | | | | 13.5 | 16 | | | |
| | 48 | 48 | | | | | 13.5 | 17 | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Abutilon* | 63.5 | 65 | 41 | 10 × .7 | *Acalypha* | 48 | 47 | 32 | 10 × .8 |
| " | $2^{27}$ | $2^{28}$ | 20 | 10 × 1.0 | " | 63 | 65 | 26 | 10 × .9 |
| " | $1^{58}$ | $2^{56}$ | 28 | 10 × .7 | *Salix* | 6 | 7 | 53 | 10 × 1.0 |
| " | $1^{34}$ | $1^{36}$ | 38 | 10 × .8 | *Ailanthus* | 8 | 7 | 29 | 10 × .9 |
| *Taxus* | $1^{20}$ | $1^{19}$ | 48 | 10 × .8 | *Cornus* | 7.5 | 6.5 | 71 | 10 × .9 |
| | $1^{22}$ | $1^{21}$ | | | | 8 | 7 | | |
| | $1^{21}$ | $1^{20}$ | | | | 8 | 7 | | |
| | $1^{20}$ | $1^{22}$ | | | | 7 | 8 | | |
| | $1^{21}$ | $1^{23}$ | | | | 7 | 8.5 | | |
| | $1^{21}$ | $1^{23}$ | | | | 8 | 9 | | |
| *Taxus* | $3^{30}$ | $3^{45}$ | 25 | 10 × .6 | *Cornus* | 13 | 13 | 39 | 10 × 1.0 |
| " | $2^{40}$ | $2^{43}$ | 42 | 10 × .6 | " | 12 | 13 | 51 | 10 × .8 |
| " | 12 | 12 | 105 | 10 × 1.0 | " | 13 | 14 | 48 | 10 × .7 |
| " | 59 | 58 | 52 | 10 × .8 | *Viburnum* | 73 | 71 | 38 | 10 × .6 |
| | | | | | | 36 | 38 | 64 | 10 × 1.0 |

The experiments given in the first table are examples from a great number that have been performed in our laboratory and are representative of the variation and extent of the resistance that the transpiration current must overcome. The stems were usually tested after standing over night in water or less commonly three or four hours in water. In the first column opposite the name of the plant is recorded the transpiration rate. In four examples, *Abutilon*, *Acalypha*, *Taxus* and *Cornus*, six consecutive readings are given to show the variations that are characteristic of the transpiration rate when conditions are as constant as possible and for comparison in the second column are six readings from a length of stem under pressure. In the other examples averages only of a series of readings are given. The pressure required to produce the rate approximating that of transpiration is found in the third column and in final division are the dimensions in cm. of the stems subjected to the pressure. In the majority of these and subsequent experiments filtered tap water was used and fresh cuttings of the ends of the stems were made in setting up the experiments if any considerable lapse of time intervened sufficient to produce a marked variation in the readings. In the case of stems under pressure this was very quickly effected, and distilled water gave the same though slower declines. This difference in the rates of consecutive readings shown in columns 1 and 2 are rather suggestive of the processes employed in maintaining the current in transpiring stems. Pressures result in a fairly constant rate. The same is true of suction. In some of the experiments under

discussion, also in tables 2 and 6, the pressure was replaced by attaching the stems to an air pump and recording the amount of suction required to draw water through the stem at the transpiration rate. The results are the same in either case. The transpiration current is an irregular one not indicative of a pull or pressure while the distribution of water in the stem can hardly be reconciled with the existence of such a condition.

Another interesting feature is the wide variation in the resistance of the stems, not alone of various plants but of the same species.

The tests were made on vigorous stems, entirely free of branches below, such as may be obtained from vigorous plants. In such cases the wood is exceptionally regular owing to the early suppression of all lateral organs. In some instances, however, the cause of the variations of rate was apparent, on splitting the stems, in irregularities of growth due to branching or other causes. The presence of these resistances becomes more apparent if transpiring stems are allowed to imbibe solutions of eosin when the difficulty of the fluid in passing the nodes or any obstruction due to irregularities in the grain of the wood is very apparent. More frequently the cause of the resistance cannot be accounted for on this ground and must be due to the specific pecularities of the individual elements rather than to any grouping of tissues that is apparent to the eye. Such may be the explanation of the high resistance of *Pelargonium* for there is sufficient carrying capacity in the water conduits to render unnecessary the high pressure required.

While as a rule the resistance increases with the rate there is no regularity in this ratio, as will be noted in comparing the second and third columns. However, it is to be noted that when a given pressure produces a certain rate of flow any increase or decrease of pressure causes about the same fluctuations of rate as would be found in capillary tubes. Two examples will illustrate this relation, the first number to the left being the pressure and the succeeding ones in the same line the rate of transmission.

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Acalypha* | 24 | 63 | 63 | 64 | 65 | 65 | *Taxus* | 58.6 | 61 | 61 | 61 | 62 | 62 | 63 |
| | 30 | 55 | 55 | 56 | 56 | 57 | | 68.6 | 51 | 51 | 51 | 51 | 52 | 52 |
| | 36 | 48 | 48 | 48 | 49 | 49 | | 78.6 | 45 | 45 | 44 | 45 | 46 | 46 |
| | 42 | 42 | 43 | 43 | 44 | 44 | | 48.6 | 77 | 77 | 77 | 77 | 78 | 78 |

## RELATION OF LENGTH TO PRESSURE

The following experiments illustrate the variations in resistances of different portions of the same stem. As in the first table the transpiration rate follows the name of the plant, in the second column is the rate obtained by pressure, next the pressure employed and the dimensions of the stem. Columns 5, 6 and 7 give the rates when $\frac{1}{4}$, $\frac{2}{4}$ and $\frac{3}{4}$ respectively of the stem had been removed.

II.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| *Abutilon* | 38.5 | 42 | 79 | 40 × 1.1 | 32 | 27 | 23 |
| | 40 | 42 | | | 32.5 | 26.5 | 23 |
| | 41 | 42.5 | | | 32.5 | 27 | 23.5 |
| | 39 | 42.5 | | | 32 | 27.5 | 23 |
| | 39.5 | 43 | | | 32.5 | 27.5 | 23 |
| | 40.5 | 43 | | | 32 | 28.1 | 25.5 |
| *Abutilon* | $2^{1}$ | $1^{38}$ | 66.5 | 40 × .9 | 52 | 20 | 15 |
| " | $1^{47}$ | $1^{43}$ | 37.4 | 40 × .8 | $1^{26}$ | 58 | 34 |
| *Syringa* | 60 | 61 | 220 | 40 × .8 | 34 | 30 | 15 |
| | 58 | 61 | | | 34 | 31 | 16 |
| | 56 | 63 | | | 35 | 31.5 | 16 |
| | 59 | 64 | | | 35 | 31 | 17 |
| | 58 | 64 | | | 36 | 31.5 | 18 |
| | 58 | 64 | | | 39 | 32 | 18 |
| *Syringa* | 58 | 61 | 190 | 30 × 1.0 | 43 | 30 | 21 |
| " | $4^{50}$ | $4^{50}$ | 103 | 30 × 0.6 | $2^{30}$ | $1^{20}$ | 40 |
| *Viburnum* | 63 | 58 | 195 | 40 × .6 | 43 | 39 | 16 |
| | 61 | 58 | | | 44 | 40 | 15 |
| | 60 | 59 | | | 43 | 38 | 15 |
| | 59 | 60 | | | 41 | 39 | 16 |
| | 62 | 59 | | | 41 | 38 | 16 |
| | 61 | 59 | | | 40 | 39 | 16 |
| *Viburnum* | 56 | 65 | 186 | 40 × 1.0 | 20 | 16 | 9 |
| " | 48 | 48 | 222 | 40 × .9 | 31 | 20 | 15 |
| *Pelargonium* | $1^{5}$ | $5^{37}$ | 186 | 40 × 1.0 | $2^{34}$ | $1^{27}$ | $1^{4}$ |
| | $1^{9}$ | $5^{52}$ | | | $2^{34}$ | $1^{28}$ | $1^{8}$ |
| | $1^{6}$ | 6 | | | $2^{35}$ | $1^{26}$ | $1^{6}$ |
| | $1^{10}$ | $5^{58}$ | | | $2^{37}$ | $1^{27}$ | $1^{6}$ |
| | $1^{8}$ | $5^{56}$ | | | $2^{38}$ | $1^{28}$ | $1^{7}$ |
| | $1^{5}$ | $5^{56}$ | | | $2^{38}$ | $1^{28}$ | $1^{8}$ |
| *Pelargonium* | $1^{30}$ | $3^{55}$ | 186 | 40 × .9 | $2^{12}$ | 42 | 23 |
| " | $1^{22}$ | $3^{10}$ | 186 | 40 × .8 | $2^{26}$ | $1^{58}$ | $1^{38}$ |
| " | $1^{20}$ | $1^{24}$ | 186 | 20 × 1.0 | 47 | 26 | 14 |

Here again it is evident that only in the remotest way is there any conformity to the law of Poiseuille for capillary tubes, at least the ratio of rate, length, radius and pressure can hardly be said to show a variation in conformity to this law. Some stems offer a resistance out of all proportion to their dimensions and the volume of transpiration. *Pelargonium* is a striking example of this. It is possible that this may be due in part to blocking by substances escaping from the cut stems. In other instances equally striking examples are sometimes met, the pressures ranging from .08 to .2 of an atmosphere per sq. cm. in the short lengths of stems mentioned above. The irregularities shown in the 2d, 5th, 6th and 7th columns of the first experiment with *Viburnum* are doubtless due to the fact that the negative pressure was not satisfied. It was frequently noticed in such cases and particularly with stems tested in the winter that they would show for hours an irregularity and even an acceleration of rate. The rapid decline in the rate in the short lengths is, of course, due to increased volume transmitted.

## ELECTRICAL CURRENTS AND CONDUCTIVITY

In some work, conducted two years ago at the Physical Laboratory, a slight difference of potential was shown to exist between the top and bottom of trees. Haacke has also demonstrated the presence of weak currents circulating in the plant cells. In view of these facts and the marked effect of electrical currents upon plants, lengths of stems under pressure and also transpiring stems with potometer attached were submitted to currents from a double 18-inch plate, Winshurst static machine and also to the street current, 110 volts. The current was applied to the stems by removing two strips of the cortex 10 cm. apart and wrapping the electrodes about the wood.

III.

| | C | | C | | | RC | | RC |
|---|---|---|---|---|---|---|---|---|
| *Acalypha* | 39 | 39.5 | 42 | 39.5 | 52.5 | 54 | 54 | 56 |
| | 39.5 | 40.5 | 41.5 | 40.5 | 53 | 53 | 56.5 | 55 |
| | 39.5 | 40.5 | 42 | 40.5 | 54 | 53 | 57 | 54.5 |
| | 39 | 41.5 | 39.5 | 40.5 | 54 | 51 | 56 | 54 |
| | 39 | 41.5 | 39 | 41 | 54.5 | 51 | 57.5 | 53 |
| | 38.5 | 42 | 39.5 | 41.5 | 55 | 51 | 57.5 | 54 |
| | 38 | 42 | 38 | | | | | |

| | | C | | C | | C | | C | | C. |
|---|---|---|---|---|---|---|---|---|---|---|
| *Abutilon* | 57 | 55 | 60 | 57 | 63 | 59.5 | $1^{40}$ | $2^{29}$ | $2^{34}$ | $2^{31}$ |
| | 56 | 55 | 60 | 57 | 62 | 60 | $1^{50}$ | $2^{30}$ | $2^{31}$ | $2^{30}$ |
| | 57 | 54 | 60 | 56 | 61 | 58 | $2^{20}$ | $2^{28}$ | $2^{29}$ | $2^{29}$ |
| | 57 | 54 | 61 | 56 | 61.5 | 59 | $2^{22}$ | $2^{27}$ | $2^{32}$ | $2^{29}$ |
| | 56.5 | 54.5 | 61 | 56 | 62 | 58.5 | $2^{25}$ | $2^{26}$ | $2^{35}$ | $2^{30}$ |
| | 57 | 54 | 62 | 55 | 62 | 59 | $2^{26}$ | $2^{28}$ | $2^{36}$ | $2^{30}$ |

The columns marked C give the rate with the current on, RC with the current reversed, those unmarked without the current.

The results as far as showing any effect upon the conductivity of the xylem is negative. The current from the static machine and also weak dynamic currents had no effect.

The variations in the above examples which are taken from experiments with street current are due to the high resistance of the stem to the current. This resulted in a rise of temperature and the change of rate. The records of temperature in the preceding work have not been given inasmuch as the examples selected for illustration have not been subjected to any variations in this respect that are of importance. In the test upon *Abutilon*, for the purpose of producing variations in the conductivity of the stem, a 1% NaCl and an isotonic cane-sugar solution were used in place of water, the measurements with the latter occurring in the four right-hand columns. The results are the same as with water.

## SALT SOLUTIONS AND RATE

The marked influence of salt and sugar upon the rate in the last experiment led to some further tests for the purpose of determining if there was any specific peculiarity in the cell wall that might be revealed by the rate of transmission. Solutions of $ZnCl_2$ and sugar were prepared isotonic with a decinormal solution of NaCl and stems were subjected to these different solutions under constant pressure.

IV.

| | $H_2O$ | NaCl | $H_2O$ | $ZnCl_2$ | | $H_2O$ | NaCl | $H_2O$ | $ZnCl_2$ |
|---|---|---|---|---|---|---|---|---|---|
| *Taxus* | $2^{34}$ | $2^{20}$ | $2^{24}$ | $2^{18}$ | *Acalypha* | $1^{20}$ | 52 | 64 | 61 |
| | $2^{34}$ | $2^{21}$ | $2^{25}$ | $2^{21}$ | | $1^{19}$ | 52 | 69 | 59 |
| | $2^{34}$ | $2^{32}$ | $2^{32}$ | $2^{31}$ | | $1^{18}$ | 51 | 70 | 59 |
| | $2^{35}$ | $2^{35}$ | $2^{34}$ | $2^{40}$ | | $1^{18}$ | 50 | 72 | 62 |
| | $2^{35}$ | $2^{34}$ | $2^{35}$ | $2^{34}$ | | $1^{19}$ | 49 | 74 | 63 |
| | $2^{35}$ | $2^{34}$ | $2^{40}$ | $2^{36}$ | | $1^{19}$ | 49 | 78 | 63 |

| | $H_2O$ | $C_6H_{22}O_{11}$ | $H_2O$ | NaCl | | $H_2O$ | $C_6H_{22}O_{11}$ | $H_2O$ | $ZnCl_2$ |
|---|---|---|---|---|---|---|---|---|---|
| *Taxus* | 33 | 48 | 53 | 50 | *Acalypha* | 50 | 52 | 62 | 59 |
| | 33 | 54 | 54 | 50 | | 51 | 54 | 63 | 58 |
| | 33 | 58 | 56 | 51 | | 51 | 61 | 62 | 58 |
| | 34 | 61 | 60 | 51 | | 52 | 62 | 62 | 62 |
| | 33 | 73 | 61 | 50 | | 52 | 63 | 63 | 62 |
| | 33 | 74 | 62 | 51 | | | | | |

The few examples here given are typical of the variations resulting upon a change of solution. The results seem to indicate that in the case of NaCl and $ZnCl_2$ there is not apparent any specific relationship between the wall and any of the substances different from that existing between the wall and water. Investigations upon this point have not been completed. The accelerating effect following the substitution of salt solutions for water appears to be due to the osmotic action of the two fluids thus brought together acting through the walls of the living cells. The fact that the rate often accelerated for some time but finally declined would indicate this relation. It is not probable that the dead cells play any rôle in the acceleration of the rate. The measurements with sugar, however, indicate that the molecules are not freely transmitted and so act as an effectual block to any osmotic action while the introduction of another solution would tend to remove the obstruction and allow a renewal of osmotic action in the cells. This result would appear to throw considerable light upon the manner of transmission of sugars through the stem and account for their meager occurrence in the sap.

Solutions of 50 per cent. alcohol had a very marked effect upon the conductivity of the cells, causing a marked and rapid decline which was not changed with the introduction of water. Thus with a rate of 46, 46, 47, 47, 47 under water pressure, with alcohol the readings were 60, 61, 63, 63, 64, followed with water 82, 83, 84, 85, 85. The results are evidently due to a molecular change in the walls whereby their power of transmission has been materially interfered with. The feeble attraction between the alcohol and the molecules of the cell wall would tend to prevent imbibition and doubtless leaves them less attractive to water.

### TEMPERATURE AND RESISTANCE

For the purpose of comparison with effects upon capillary tubes, observations were made upon the action of temperatures on

the conductivity of stems. In the first example the stem above the potometer for about 35 cm. was covered with a layer of snow about 2 cm. thick and bound with sheet rubber so that there could be no drip upon the potometer. A thermometer was placed among the leaves, 5 cm. above the jacket of snow in order to determine whether any variation of rate could be explained by a lessened action of the transpiring organs rather than by the increased resistance of the stem. The snow was applied for about one half hour, producing a fall of temperature among the leaves of only 2.8 degrees. The wide variation from the normal transpiration rate of 16.4 to 36.2 cannot of course be attributed to so slight a fluctuation of temperature and the delayed approach to the normal rate also clearly indicates that the greatly reduced temperature of the stem is the chief factor in the reduction of the rate. It is apparent that the wide variation is not at all in keeping with the fluctuations to be noted in capillary tubes and the marked changes of rate may probably be accounted for as principally due to reduction in the size of the cell cavities.

V.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Abutilon* | 16 | $12^{50}$ | 20.5° | 19.6 | $1^{10}$ | 18.6° | 35 | $1^{25}$ | 17.7° | 34.6 | $1^{40}$ | 19.4° |
| | 16 8 | | | 20.2 | | | 36.2 | | | 33.8 | | |
| | 16.5 | | | 21 | | | 36 | | | 34.5 | | |
| | 16 | | | 22.5 | | | 37 | | | 33.4 | | |
| | 16.4 | | | 23 | | | 36.4 | | | 32 | | |
| *Citrus* | 25 | $11^{20}$ | 18.3° | 28. | $11^{45}$ | 15.5° | 33.5 | 12 | 16.5° | 27 | $12^{20}$ | 19.4° |
| | 26 | | | 28.6 | | | 33.5 | | | 26 | | |
| | 25.6 | | | 31. | | | 33.5 | | | 25 | | |
| | 26.2 | | | 32. | | | 33 | | | 25.5 | | |
| | 26 | | | 32.5 | | | 33 | | | 24. | | |
| *Abutilon* | 55 | $2^{20}$ | 23° | $1^{20}$ | $2^{30}$ | 8° | $1^{25}$ | $2^{50}$ | 20.6° | | | |
| | 56 | | | $1^{33}$ | | | $1^{20}$ | | | | | |
| | 56 | | | $1^{35}$ | | | $1^{11}$ | | | | | |
| | 57 | | | $1^{34}$ | | | $1^{6}$ | | | | | |
| | 56 | | | $1^{34}$ | | | $1^{2}$ | | | 22 | | |
| *Abutilon* | 54.3 | $3^{15}$ | 24.7° | $1^{10}$ | $3^{40}$ | 8° | $1^{14}$ | $3^{30}$ | 12° | 13 | $4^{20}$ | 21° |
| | 54.5 | | | $1^{13}$ | | | $1^{8}$ | | 14° | 1 | | 23° |
| | 55 | | | $1^{15}$ | | | $1^{8.5}$ | | | 58 | | |
| | 54.5 | | | $1^{18}$ | | | $1^{7}$ | | | 58 | | |
| | 54.5 | | | $1^{19}$ | | | $1^{6}$ | | 16° | 56 | | 24° |

The branch of *Citrus* was treated in the same way, about 20 cm. of the stem being covered with snow, with practically the same results. It is to be noted that the rise of temperature in the room

during the experiment was sufficient to cause a much quicker acceleration of rate than in the preceding example.

In the third experiment a length of stem immersed in water at 23° was tested under pressure. The rate of 55.8 was lowered, when the stem was covered with water at 8°, within five minutes to $1^{20}$, and dropped rapidly to $1^{34}$. Water at 25° was now introduced and the first measurement a few minutes later showed a rate of $1^{25}$ followed by a sharp rise. The temperatures given are probably near those of the stem since the thermometer was lying in the dish against the stem and they would not vary materially in taking on the temperature of the surrounding media. The final test illustrates the variations of rate at different temperatures. The readings are not consecutive. The results are rather suggestive as indicating the very considerable additional work placed upon the plant by variations of temperature. These changes are often sudden and not only act upon the transpiring organs but also introduce a very considerable resistance that is frequently overlooked.

## RESISTANCE INTRODUCED BY CUTTINGS

The localization of resistances noted above led, for the purpose of comparison, to measurements on the effect of the introduction of resistances by cutting. The tests were confined to *Taxus* as these plants will better stand the treatment without flagging. In the first column is given the transpiration rate of the branch and in the second and third columns the rates when the stem was cut ½ and ¾ through. The fourth column shows the rate when the column was reduced to a few sq. mm., indicated at the right of the column.

VI.

| | | | | sq. mm. | | | | | | | sq. mm. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Taxus* | 8 | 9 | 14 | 13 | 6 | 9.5 | 24 | 12 | 19 | 29 | 8 | 8 × 1.5 |
| | 8.1 | 9.5 | 13.5 | 12.8 | | 10 | | 14 | 20 | 34 | | |
| | 8 | 8.9 | 13.2 | 12.2 | | 9 | | 16 | 20 | 34 | | |
| | 8.4 | 8.4 | 13 | 13 | | 9 | | 16 | 20 | 37 | | |
| | 8 | 8.9 | 13.6 | 13 | | 10 | | 15 | 21 | 36 | | |
| | 8.2 | 9 | 12 | 13 | | 10.5 | | 14 | 22 | 37 | | |
| *Taxus* | 28.5 | 29.5 | 30.8 | 35 | 2 | 29 | 15 | 44 | 90 | 184 | 7 | 7 × .9 |
| | 28 | 29 | 30.4 | 36 | | 30 | | 45 | 98 | 196 | | |
| | 29.2 | 29 | 30 | 35 | | 29.5 | | 48 | 102 | 186 | | |
| | 28.5 | 28.5 | 30.1 | 39 | | 29.5 | | 46 | 96 | 200 | | |
| | 28.4 | 29 | 29.5 | 36 | | 30 | | 47 | 98 | 189 | | |
| | 28.5 | 28.5 | 30 | 36 | | 29 | | 46 | 98 | 198 | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Taxus* | 6.7 | 8 | 13.6 | 15.5 | 9 | 7.2 | 58 | 15.6 | 34 | 52 | 8 | 7 × 1.0 |
| | 7 | 7.5 | 13.9 | 15.5 | | 7.2 | | 17 | 36 | 58 | | |
| | 6.8 | 7.5 | 12.2 | 16 | | 7.4 | | 18 | 36 | 59 | | |
| | 7 | 7 2 | 13.8 | 15.6 | | 7.4 | | 17 | 35 | 59 | | |
| | 7.2 | 7.1 | 12 | 15.1 | | 7.4 | | 18.2 | 37 | 60 | | |
| | 7.2 | 7.1 | 11.6 | 15.6 | | 7.4 | | 18.5 | 36 | 61 | | |

The second part of the table gives the results when lengths of stems under pressure were treated in the same way. The number to the right of the first column indicates the pressure required and the three succeeding columns record the results of cutting ½ and ¾ through and to a few sq. mm. The final numbers give the dimensions of the stem. The lengths of these stems also indicate the distance above the potometer at which the cuttings were made.

These cutting experiments of Dufour are among the most important that can be performed in transpiration since they give a very clear demonstration of the vital action of the living cells in maintaining the transpiration stream. The recovery from the effect of cutting noted in the first part of the table is entirely done away with in the second series of measurements upon the stems under pressure. In fact the results in this latter case are practically the same as those obtained in the different lengths of stems in Table II. These results were certainly not to be expected and may be accounted for, I believe, on the ground that the velocity of the fluids at the point of cutting is so enormously increased that a resistance is generated quite out of proportion to that acting on the stem at the normal rate and sufficient to reduce the rate practically to that of stems increased in length in proportion to the depths of cutting.

## RELATION OF CONDUCTING AREA IN STEM TO VOLUME OF FLUID

The ability of the plant to maintain the water current unchecked through so small an area of stem led to some investigation upon the extend of the area at the disposal of the plant for the conduction of fluids and the precentage of this space actually utilized. To determine the percentage of cavity in the stem microscopic cross sections were prepared and areas, representative of the various growths of the stem were drawn on sheets of tinfoil with a camera

lucida. The weight of the areas bearing the tracings of the wood sections having been determined, by cutting out the lumen of the cells and determining their weight, the percentage of cavity could be determined. This appears to be fairly accurate. The tinfoil selected showed but slight variations in weight and the tracings, cutting and weighing can be made with accuracy. In the following experiment with *Acalypha* a potted plant was placed in a glass jar and the mouth of the jar covered so as to prevent evaporation from the soil. The amount of transpiration for two hours was found to be at the rate of 7.1 grm. per hour. The stem was then cut under water and allowed to stand three hours. It was then allowed to absorb water from a florence flask plugged with cotton for two hours, the loss per hour being 4.53 grm. The stem being transferred to a solution of eosin for one hour the ascent of the fluid was found to be 75.4 cm. From cross sections of the stem the following area of lumen and percentage of cavity was obtained:

| | | |
|---|---|---|
| Weight of area adjoining pith | 3.030 | |
| " " cavity in this area | 1.726 | Percentage of cavity 56.9 |
| Weight of area in middle of xylem | 3.047 | |
| " " cavity in this area | 1.709 | Percentage of cavity 56.1 |
| | | Average 56.5. |

The area of the cross section of the stem was 23.15 sq. mm. This would give a water conduit of 13.08 sq. mm.

It is interesting to note the relation of this latter area to the rise of eosin in the stem and the absorptions both in the case of the cut and uncut stem. Taking the rise of the eosin, 75.4 cm. as an approximation of the rate of absorption of the cut stem it is seen that only 6.01 sq. mm. would be required to carry 4.53 grm. to a height of 75.4 cm. Considering the absorption of the uncut branch if the entire area at the disposal of the stem for the conduction were utilized the 7.1 grm. would rise only 54.2 cm.

Two similar tests were made on *Abutilon*. The potted plant transpired 3.25 grm.; cut, 2.95 grm. per hour. Percentage of cavity, 50.1. Area of wood, 37.75 sq. mm. Area of cavity 18.91 sq. mm. 3.25 grms. would consequently rise 17.18 cm. if entire area was utilized. Recorded rise of eosin, 23.5 cm. This would require an area of 13.84 sq. mm.

Another plant transpired 4.73 grm.; cut, 3.9. Percentage of cavity, 55.6. Area of wood, 47.56. Area of cavity, 26.45. This would necessitate a rise of only 17.5 cm. while the eosin solution reached a height of 43.4 cm., requiring an area of 10.1 sq. mm.

A branch of *Taxus* was tested in the same way. Measurements of different sections from the cross section of the stem gave exceptionally uniform results. The area of the wood, 29.3 sq. mm. Percentage of cavity 35.5. Area of cavity, 10.40 sq. mm. Absorption by stem 2.19 grm. The rise therefore would be 20.2 cm. Recorded rise of eosin 31 cm.; necessitating an area of 6.77 sq. mm. It should be stated that the above-mentioned tests were made on plants with small transpiring leaf areas, as the amount of absorption indicates.

It will be seen that the percentages secured in these experiments correspond in the main with results obtained by Rb. Hartig and Sachs and it would appear that there is less opportunity for the introduction of error in this method while in addition the directness of obtaining the results renders the process more available than the specific gravity method.

It is very evident that the carrying capacity of the water conduits is greatly in excess of any demands made upon it by the plant and it is reasonable to suppose that the proportions expressed above between the volume of water and the area of cavity of the stems fairly represent the conditions that obtain in these plants. It will be noted that the percentage of air space is not necessarily larger in the more actively transpiring plants. These relations render quite unnecessary the supposition of Vines that the walls under certain conditions may serve as channels in the transmission of water.

## SUMMARY

By means of pressure tests a definite measure of the resistance of a given length of stem to the transpiration current may be obtained and the work actually performed by the plant can be computed. More frequently in the case of small plants by the lifting method of measuring this force a partial estimate of what the plant can do rather than what it is doing is obtained.

The resistance overcome by the transpiration current is often much higher than can be measured by the suction of the transpiring shoot and is subject to extensive variations in different species

of plants and among plants of the same species. Various parts of a stem differ widely in the resistance offered and consequently there is no ratio in the rate of transmission of a stem under pressure and the length of stem.

The rate of transmission is not affected by electric currents and various solutions as in capillary tubes. The former has no effect while the relation of the character of the wall to the nature of the solution may have a marked effect in the rate of transmission. Changes of temperature produce marked fluctuations in the amount of resistance, due largely to variations in the lumen area of the cells.

Partial severing of the water conduits by cuttings does not produce variations in the rate corresponding to those brought about by constricting the bore of tubes at a given point. On the contrary the resistances so introduced are practically equivalent to an increase in the length of the stem proportional to the extent of the cutting. Only a portion of the lumen area is utilized by the plant. This condition may be maintained within certain limits either in slowly or actively transpiring plants through variations in the rate of transmission.

# Studies in North American Discomycetes. I. The Genus Holwaya Sacc.

By Elias J. Durand

(With Plate 26)

In the autumn of 1895, I collected a discomycete on a large prostrate log in the vicinity of Ithaca, which I determined at the time as *Holwaya ophiobolus* (Ellis) Sacc., since it agreed in all respects with the specimens in Ellis's N. A. F., No. 996. My plants were accompanied by a Hyphomycetous fungus referable to genus *Graphium*. The possible connection of the two forms suggested itself to me at the time, but I thought no more about it until the winter of 1898, when Professor Burt read a paper before the Society for Plant Morphology and Physiology, at Ithaca, on the subject, "Is there a Basidiomycetous stage in the life history of some Ascomycetes?" Since that time I have been collecting notes and observations on which the present paper is based.

The genus *Holwaya* was described by Saccardo in 1889, to include a Bulgariaceous discomycete externally resembling *Bulgaria inquinans* (Pers.) Fr., but differing from it in the possession of filiform, multiseptate spores. The genus was based on *Bulgaria ophiobolus* Ell., which had already been described from material collected in Iowa by Holway, and distributed in Ellis's N. A. F., No. 996. According to the original description the plant is "composed of two layers, separated by a gelatinous stratum." This gelatinous character was not evident in my material (Fig. 8).

A second species in the genus, *H. tiliacea* E. & E., was described in 1897, from material collected in Canada, on the bark of dead *Tilia*. The differences between this and the first species are not very evident from the descriptions. In 1899, Professor Burt sent me specimens collected on basswood logs, at Middlebury, Vt., and determined by Mr. Ellis as *H. tiliacea* E. & E. In an accompanying note Professor Burt said that he did not see

why *H. ophiobolus* was not the same thing. After a careful comparison of this material with that in the N. A. F., No. 996, I must confess that I can detect no difference. They are alike in all essential respects (Fig. 7).

In 1878, Dr. Peck described a discomycete collected on rotten maple bark, which he called *Patellaria leptosperma* Pk. Saccardo later transferred this species to *Lecanidion* on account of its hyaline spores. It is interesting to note that some of Professor Burt's material already mentioned was sent to Dr. Peck, who named it *Lecanidion leptospermum* (Pk.) Sacc. Furthermore, I recently sent some of my 1895 collection to Dr. Peck, with the request that he compare it with his species. He referred it to *Patellaria leptosperma*. Dr. Peck was also good enough to send me specimens of this species, collected at Copake, N. Y. They agree in every respect with the specimens mentioned in the preceding paragraphs (Fig. 6).

But this is not all. In 1893, there was published under the name *Chlorosplenium Canadense* E. & E. the description of a discomycete collected in Canada, on rotten basswood bark, by Prof. John Dearness. According to the descriptions this seems to differ from *Holwaya* principally in the tomentose stem. Mr. Dearness very kindly sent me recently three specimens from as many gatherings, all of which evidently belong to the same species. One of these specimens was a part of the original material from which *C. Canadense* E. & E. was described. Although the specimen is too young to show spore characters, in all other respects it agrees with specimens of *Holwaya ophiobolus*, *H. tiliacea*, and *Lecanidion leptospermum*. The original description of the spores shows that they, also, are alike. The other specimens from Mr. Dearness exhibit these characters plainly (Fig. 5). With regard to the tomentose character of the stem, a study of specimens has revealed the presence of the olive-brown tomentum on the stems of all examined. In the structure of the sterile layers of the ascoma we find further evidence of the specific identity of these plants. I have made careful paraffin sections of specimens from Professor Burt, from Ellis's N. A. F., No. 996, and of plants collected at Ithaca in 1900, and find that the structure is exactly the same in all. (Fig. 3). In the light of what has been said, therefore, I cannot

but regard *Holwaya ophiobolus* (Ell.) Sacc., *H. tiliacea* E. & E., *Lecanidion leptospermum* (Pk.) Sacc., and *Chlorosplenium Canadense* E. & E. as one and the same species.

Turning now to the subject of a conidial phase of this species, I find that a plant called *Stilbum giganteum* Peck was described in 1871. Saccardo, however, transferred it to the genus *Graphium*. The first mention of this plant as a possible imperfect stage of an ascomycete was made by Dr. Peck in his thirty-first report written in 1878, where he said: "I find this associated with *Patellaria leptosperma* Pk. in such a way as to suggest the probability, at least, that it is a form of the latter species." Ellis and Everhart in their descriptions of *Chlorosplenium Canadense* and *Holwaya tiliacea* in each case call attention to the fact that *Coryne Ellisii* Berk. (*Stilbum magnum* Pk.) was found associated with the species, of which it might be a conidial stage. As a matter of fact the association of the two forms has been noted in the great majority of the records of occurrence. The fact that it has not been mentioned in the other cases does not, by any means, go to show that they were not growing together, for such association might have been overlooked. Regarding "*Stilbum magnum* Pk.," Dr. Peck assures me that he never has published such a species, but that the occurrence of the name in the literature is probably due to a slip of the mind or pen, *Stilbum giganteum* being intended in each case.

*Coryne Ellisii* Berk. was published in 1873 from material found by Ellis, on basswood logs, at Potsdam, N. Y. No asci were present in the original specimens, but the plant was referred to *Coryne* probably on account of a superficial resemblance to the members of that genus. Indeed, Berkeley remarked that an examination of fresh material was desirable. The matter was further greatly complicated when Massee, in 1894, redescribed the type of *Coryne Ellisii*, making it one of the types of a new genus of the Basidiomycetes, called *Dacryopsis*. Our plant was given the name *D. Ellisiana* Massee. The basidia were described as "cylindrical, bifurcate, aseptate, springing from the interlaced layer of hyphae at the apex of the stem, either contemporaneous with, or later than, the gonidiophores."

Such was the state of knowledge regarding this plant when

Professor Burt presented the paper mentioned in the first paragraph. His conclusions may be summarized as follows: "Specimens of the *Dacryopsis* collected in August, October, November and December show only the conidial condition, and no true basidia and basidiospores. Until the presence of basidia is demonstrated, *Graphium giganteum* (Pk.) Sacc. should be regarded as a conidial rather than a basidiomycetous stage of the ascomycete *Lecanidion leptospermum* (Pk.) Sacc." My own results only confirm those of Professor Burt. I have examined many specimens of the *Graphium* from several localities, and of various ages, and have made careful paraffin sections, but as yet I have found no structure which might be interpreted as a basidium.

In the autumn of 1900, specimens of the *Holwaya* were found growing on a rotten basswood log in woods not far from Ithaca. A few days later others were found on oak in the same woods. The *Graphium* was present in both cases. Inasmuch as it seemed desirable to determine definitely, if possible, the relation between the two forms, cultures were made from the specimens on oak in the following manner: Agar was prepared using a decoction of dead oak bark as a nutrient base. A bit of the hymenium was then taken up with a sterilized scalpel, and crushed in boiled water on a flamed slide. Dilution cultures were made on acidified medium in the usual manner. The same was done with the conidia. Ascospores were present in considerable numbers, and could easily be recognized in the agar, with the aid of the microscope. The cultures were examined at intervals for two or three days, but no signs of germination appearing, they were, unfortunately, neglected for a day or two. When next they were examined, numerous small colonies were present in the cultures of the ascospores. Examination with the microscope showed that the spore could still be made out in the center of many of the colonies, with threads actually attached to it, although some of the colonies were so far advanced that the spore was obliterated. There could be no doubt, therefore, that the colonies came from the ascospores. The cultures were allowed to stand a week, when it was found that plate number two of the set contained a pure culture, except for a single colony of *Penicillium*. Some of the colonies were then carefully transferred to

sterilized bean stems, and dead oak stems and bark. On the bean stems growth was very slow, but after a week, mycelial threads could be seen extending into the liquid at the bottom of the test-tube. Soon these formed a felty mass on the surface of the water. After two weeks minute dark points appeared on the bean stems. These rapidly increased in size, until they assumed all the appearances of normal *Graphium giganteum*, except that they were smaller than those grown under natural conditions. This was to be expected. Examination with the microscope revealed conidia in great numbers, and of the normal form, borne on conidiophores likewise normal. No growth occurred on the oak bark. The original cultures of the conidia failed to produce germination. Attempts to repeat the germination of the ascospores also failed. As yet after more than three months no ascomata have appeared.

These cultures seem to remove all doubt that *Graphium giganteum* (Pk.) Sacc., and the ascomycete forming the genus *Holwaya* are different stages in the development of the same plant. The question now arises, What shall this plant be called? The first name applied to the *ascus* stage was *leptosperma* Peck. If that name be applied our plant would be called *Holwaya leptosperma* (Pk.) Durand. But if the first name applied to the plant *in any of its forms* be used, it should be called *Holwaya gigantea* (Pk.) Durand. The latter combination seems the more logical, and has the sanction of precedent. But what is the systematic position of the plant? It has already been placed in three different families, viz.: Pezizaceae, Patellariaceae and Bulgariaceae. Saccardo placed it in the last-named group on account of its "gelatinous stratum" mentioned in the first description of *Bulgaria ophiobolus* Ellis. I have examined a large number of plants, both fresh and dry, but I cannot detect any indication of a gelatinous nature; certainly none such as exists in *Bulgaria* or *Coryne*. On the contrary the substance is rather a fleshy-mealy when fresh, becoming hard and brittle when dry. The flesh is dark brown in color. A section shows that the paraphyses are longer than the asci, and cohere at the tips into a thick black epithecium covering the hymenium. These characters locate it in the Patellariaceae where Dr. Peck first placed it. This, I think, is its proper position. *Holwaya* is

nearest related to *Lahmia* Körb., from which it differs in its stipitate habit, dark hypothecium, and tomentose stem.

I add a description and synonymy.

HOLWAYA Saccardo, Syll. Fung. **8**: 646. 1889

A genus of the Patellariaceae. Ascomata stipitate, stipe tomentose; hypothecium and excipulum dark brown; sporidia 8, hyaline, filiform, multiseptate, not breaking up at maturity.

**Holwaya gigantea** (Peck) Durand

Ascus form.

*Patellaria leptosperma* Peck, Reg. Rep. **30**: 62. 1878.

*Bulgaria ophiobolus* Ellis Am. Nat. **17**: 193. 1883.

*Holwaya ophiobolus* (Ell.) Sacc. Syll. Fung. **8**: 646. 1889.

*Lecanidion leptospermum* (Pk.) Sacc. Syll. Fung: **8**: 800. 1889.

*Chlorosplenium Canadense* E. & E. Proc. Phil. Acad. Nat. Sci. **41**: 146. 1893.

*Holwaya tiliacea* E. & E. Am. Nat. **31**: 427. 1897.

Conidial form.

*Stilbum giganteum* Peck, Reg. Rep. **24**: 93. *pl. 3. f. 7–9.* 1871.

*Coryne Ellisii* Berk. Grev. **2**: 33. 1873.

*Graphium giganteum* (Pk.) Sacc. Syll. Fung. **4**: 611. 1886.

*Dacryopsis Ellisiana* Massee, Jour. Myc. **6**: 181. *pl. 7. f. 19–21.* 1891.

*Ascus form.*—Caespitose or single, scattered, stipitate. Disk cup-shaped, becoming plane, or the margin reflexed and umbilicate, orbicular, or irregular from mutual pressure, when fresh .75–1.5 cm. in diameter, greenish-black, externally same color, pruinose or granular. Stem .25–.75 cm. high, tapering downward, greenish-black, covered with an olive-brown tomentum, which often disappears with age. Flesh dark brown to black. In drying the plant shrinks to less than one-half its former size and becomes black. Hypothecium well-developed, of intricately interwoven hyphae; excipulum of slender interwoven hyphae, passing into a cortical layer of pseudo-parenchyma, of polygonal cells about 10 $\mu$ in diameter, which project from the surface in groups giving it a granular appearance. This layer is confined to the sides of the cup and upper part of the stem. Stem composed of closely interwoven hyphae which project from the surface forming the tomen-

tum of septate, sparingly branched threads, 2 $\mu$ thick. Asci narrowly and evenly clavate, apex rounded, not blue with iodine, variable in size in the same individual, 120–200 × 10–12 $\mu$. Sporidia 8, fascicled or multiseriate in the ascus, filiform-cylindrical, or very narrowly clavate-cylindrical, ends rounded, or sometimes acute at one end, straight, curved, or slightly sigmoid, hyaline, multinucleate, becoming 14–20-septate into cells about as long as wide, very variable in size, 30–75 × 3–4 $\mu$. Paraphyses filiform, slender, longer than the asci, globose at the tips which cohere, and with amorphous matter form the epithecium.

*Conidial form.*—Gregarious or single, fleshy-gelatinous, stem cylindrical or tapering upward, 3–10 × 2 mm., black. Head broadly elliptical, soft, viscid, pallid, 2–6 × 2–4 mm. Conidiophores very slender, branched. Conidia hyaline, elliptical, 3 × 1 $\mu$.

On prostrate rotten logs, usually in crevices and depressions in the bark, also on the bare wood, oftenest on *Tilia*, but also on *Acer*, *Quercus* and *Magnolia*. October and November.

Vermont (Burt)!; New York (Peck!, Clinton, Durand!); Ohio (Kellerman)!; W. Virginia (Nuttall); Iowa (Holway)!; Canada (Macoun, Dearness!).

**Explanation of Plate**

Figures 2, 4, 5, 6, 7 and 8 were drawn to the same scale. Figures 1–4 are from specimens collected at Ithaca, October, 1900.

1. Longitudinal section of whole ascoma to show form and tomentose stem.

2. A portion of the tomentum, showing connection of the threads with the hyphae of the stem.

3. A longitudinal section of the cup a short distance from the margin.

4. Asci, paraphysis and sporidia.

5. Ascus and three sporidia of *Chlorosplenium Canadense* E. & E., from specimens collected at London, Canada, by Professor Dearness (no. 2032 B).

6. Asci, paraphysis and sporidia of *Lecanidion leptospermum* (Pk.) Sacc., from specimens collected by Dr. Peck, at Copake, N. Y.

7. Ascus, paraphysis and sporidia of *Holwaya tiliacea* E. & E., from specimens collected at Middlebury, Vt., by Professor Burt.

8. Ascus, paraphysis and sporidia of *Holwaya ophiobolus* (Ell.) Sacc., from specimens in Ellis's N. A. F., no. 996.

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## Shrubs and Trees of the Southern States.—IV.

By John K. Small

### 1. THE EBENACEAE IN THE SOUTH

Two types with as divergent characters as those possessed by *Diospyros Virginiana* and the so-called *D. Texana*, cannot with the least degree of systematic order, be referred to the same genus. The two plants are of wholly different habit, and the flower-structure of the two is so distinct that I cannot understand on what grounds they have been associated with each other in the same genus. The distinguishing characters of the two trees, which I shall treat as two distinct genera, may be compared by means of the following synopsis:

### EBENACEAE

A family of about 6 genera and 275 species, most abundant in tropical regions. Only the following representatives are now known to occur in the United States.

**Key to the Genera**

Styles distinct: anther-sacs opening by longitudinal slits: filaments pubescent: pistillate flowers without staminodia. 1. Diospyros.

Styles united: anther-sacs opening by subapical pores; filaments glabrous: pistillate flowers with 8 staminodia. 2. Brayodendron.

### 1. DIOSPYROS L.

1. D. Virginiana L. Sp. Pl. 1057. 1753

In woods and fields, Rhode Island to Kansas, Florida and Texas. As now limited this species may be an aggregate. One or two additional species may be separable in the south Atlantic and Gulf States.

### 2. Brayodendron *

1. **B. Texanum** (Scheele)

*Diospyros Texana* Scheele, Linnaea, **22**: 145. 1849.

Along or near streams in river valleys, southern Texas and adjacent Mexico.

* Named for Prof. W. L. Bray, head of the School of Botany, University of Texas.

2. HITHERTO UNDESCRIBED SPECIES

### Quercus microcarya

A shrub, or a small tree sometimes 5 m. tall, with very smooth branches and glabrous foliage. Leaves deciduous; blades thin, spatulate in outline, 5–10 cm. long, undulate or shallowly lobed, gray-green above, yellowish green beneath, short-petioled, the small bristles terminating the lobes early deciduous: acorns sessile, less than 10 mm. long; cup deep saucer-shaped, 6–7 mm. broad; nut globose-ovoid, often nearly one-half included in the cup.

On granite outcrops, Little Stone Mountain, Georgia.

Related to *Q. nigra*, but more delicate in all its parts. The leaf-blades are relatively thin and more irregularly lobed, while the very small acorns, always, as far as I have observed, less than 10 mm. in length, with their relatively deep saucer-shaped cups, are very distinct from the larger fruit of *Q. nigra* with its very shallow cup. The fruit is much smaller than that of any of the species of the group to which this plant belongs.

The original specimens were collected by the writer on Little Stone Mountain, Georgia, September 11, 1894. Type in the herbarium of the New York Botanical Garden.

### Quercus fusiformis

A shrub 1.5–3 m. tall, with slender or switch-like stems or branches. Leaves persistent; blades leathery, oblong or ovate-oblong, 3–5 cm. long, entire or sparingly spiny-toothed on the twigs, gray-green and lustrous above, paler and scurfy-tomentose beneath, slightly revolute, rounded or truncate at the oblique base, short-petioled: acorns numerous, solitary or several on slender peduncles; cup turbinate, 10–12 mm. high, gray; nut fusiform, 2–2.5 cm. long. long, acute, conspicuously striate, thrice surpassing the cup.

On arid limestone and granite hills, central Texas.

*Quercus fusiformis* belongs to the group formed by *Q. minima*, *Q. geminata* and *Q. Virginiana*. It is most closely related to *Q. Virginiana*, but differs in the much elongated acorn with its turbinate cup and fusiform nut.

The original specimens were collected on Lacey's Ranch near Kerrville, Texas, by Mr. Howard Lacey during the years 1899–1900, and given to me by Professor W. L. Bray, of the University of Texas. Locally known as LIVE OAK. Type in the herbarium of the New York Botanical Garden.

### Quercus Laceyi

A shrub or small tree, becoming 6 m. tall, with a rough deeply and irregularly grooved bark. Leaves deciduous but rather tardily so, numerous; blades oblong and with 3–5 shallow lobes, or oblong-obovate and more prominently 3-lobed below the apex, 4–8 cm. long, olive-green and with a waxy lustre above, grayish and slightly and minutely scurfy beneath, sometimes truncate or subcordate at the base, short-petioled: acorns sessile or nearly so; cup shallowly saucer-shaped, very thick and corky; nuts oblong to oblong-ovoid, 15–19 mm. long, often depressed at the apex: seed very bitter.

On the summits of Caprina limestone hills, north-central Texas.

Related to *Q. breviloba* but differing markedly in the glabrous leaves, the thick corky coarsely warty cup of the acorn and the oblong or ovoid-oblong nut.

The original specimens were collected on Lacey's Ranch near Kerrville, Texas, by Mr. Howard Lacey during the years 1899–1900, and given to me by Professor W. L. Bray, of the University of Texas. Locally known as BASTARD OAK. Type in the herbarium of the New York Botanical Garden.

### Quercus Brayi

A large tree sometimes 18 m. tall, or more, with a pale flaky bark. Leaves very numerous, deciduous; blades thin, cuneate, 10–20 cm. long, abruptly acuminate at the apex, regularly and coarsely sinuate-toothed nearly to the base, glabrous, with relatively few, prominent and regularly placed lateral ribs, deep green above, slightly paler and rather olive-green beneath; petioles 1.5–2.5 cm. long; acorns sessile or nearly so; cup hemispheric, 2–2.5 cm. broad, the lower scales somewhat warty on the back; nut oblong or ovoid, 2.5–3 cm. long, about 1.5 cm. thick: seed rather sweet.

In cañons, central Texas.

*Quercus Brayi* is most closely related to *Q. Michauxii*, but differs conspicuously in the membranous and glabrous leaf-blades with their few coarse teeth and lateral ribs, and the shorter and warty-thickened scales of the cup of the acorn. The original specimens were collected on Lacey's Ranch near Kerrville, Texas, by Mr. Howard Lacey in the years 1899–1900, and sent to me by Professor W. L. Bray. It is locally known as WHITE OAK. Type in the herbarium of the New York Botanical Garden.

### AEsculus austrina

A shrub several meters tall, with pubescent foliage and inflorescence. Leaf-blades 1–3 dm. broad, long-petioled; leaflets 3–5, firm or leathery, oval or oval-ovate, short-acuminate at both ends or acute at the oblique base (except in the case of the terminal one), lustrous and glabrate above, except on the tomentose nerves, densely tomentose beneath, sharply serrate, commonly quite long-petioluled: panicles 1–1.5 dm. long, tomentose: flowers deep red, about 3 cm. long: calyx tubular, red, 10–14 mm. long, glabrous; lobes ovate, rounded: petals minutely glandular, those of the upper pair with oval blades about as long as the slightly villous claws, those of the lateral pair with obovate blades which are exceeded several times in length by thair claws: stamens exerted; filaments sparingly villous.

In low grounds, Louisiana.

Most closely related to *AEsculus Pavia*, from which it differs in the foliage and flowers. It is *AEsculus Pavia β discolor* of Torrey and Gray,* in part, but not the *AEsculus discolor* of Pursh.† Torrey and Gray's disposition of this plant is the most nearly correct interpretation we have yet had. Dr. Gray later referred it to his *AEsculus flava* var. *purpurascens*, a species with which it has but distant relationship.

The specimen on which the species is founded was collected in Louisiana by Dr. Hale and is preserved in the herbarium of Columbia University.

### Hypericum interior

A much branched shrub, several dm. tall, with sharply angled branches and glabrous foliage. Leaves rather numerous; blades narrowly oblanceolate to narrowly linear-oblanceolate, 1–3 cm. long, acute, slightly revolute, pale beneath, narrowed into slender petioles: panicles many-flowered: sepals linear or narrowly oblong, 3–4 mm. long, acute, rather rigid, more or less spreading at maturity: corollas yellow, about 1 cm. broad: petals obovate or cuneate-obovate: capsules conic-ovoid, 5 mm. long.

Along streams, Tennessee and Texas. Summer.

A shrubby species related to *Hypericum galioides*, but more corymbosely branched, and with broader leaf-blades. The sepals

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* Fl. N. A. 1: 252.

† Fl. Am. Sept. 254.

are characteristic, being linear or nearly so, instead of manifestly narrowed to the base. The following specimens belong here :

TEXAS : [no locality], *Veatch.*

TENNESSEE : near Dandridge, July, 1842, *Rugel* :—type, in the herbarium of Columbia University.

### Azalea candida

A rigid shrub 1–2 m. tall, with wide-branching stems and white-tomentose young foliage, or the twigs sometimes brownish. Leaves numerous ; blades leathery, obovate, oblanceolate or oblong, 1–5 cm. long, acute or apiculate, ciliate, somewhat revolute, thinly tomentose above, densely white-tomentose and somewhat reticulated beneath, short-petioled : corymbs several-flowered : pedicels canescent and copiously glandular-pubescent : calyx-lobes pectinate-ciliate : corolla rose-colored or pinkish, 3–3.5 cm. long : capsules 1.5–2 cm. long, canescent, curved, longer than their pedicels, often twice as long.

In hammocks and river swamps, southern Georgia. Spring.

Related to *Azalea nudiflora*, but easily distinguished by the copious soft pubescence of the twigs, the white-tomentose leaf-blades, the smaller flowers and the smaller softly and closely pubescent capsules. Collected by the writer along the Withlocooche River about Valdosta, Georgia, June 6–12, 1895. Type in the herbarium of Columbia University.

### Dendrium Hugeri

An evergreen shrub 2–4 dm. tall, with erect much branched stems. Leaves mainly alternate ; blades leathery, oblong, 1–1.5 cm. long, lustrous and dark green above, paler beneath, obtuse, revolute, somewhat obliquely narrowed into petioles 1–2 mm. long: flower-clusters dense : bracts oblong-ovate, 3 mm. long, obtuse : pedicels 5–10 mm. long, minutely glandular : calyx nearly glabrous ; lobes lanceolate, about 1 mm. long, acute : corolla white ; lobes ovate, 4 mm. long, obtuse : filaments club-shaped, as long as the corolla-lobes : capsules ovoid, 4–4.5 mm. long, glabrous or nearly so, obtusely lobed, twice as long as the calyx-lobes, abruptly contracted into the stoutish style which is about as long as the capsule-body.

On cliffs and rocky mountain summits, North and South Carolina. Spring and early summer.

This overlooked species is most closely related to *Dendrium*

*buxifolium* of the Atlantic pine lands; it is, however, larger throughout and more erect. It may readily be separated by the large leaves, the filaments, which are about as long as the corolla-lobes, and the large capsule, which is about twice as long as the calyx-lobes.

NORTH CAROLINA: Top of Hibriten Mountain, Lenoir, Sept., 1896, *A. M. Huger*. Table Rock, *S. B. Buckley; Small & Heller*, 1891.

SOUTH CAROLINA: Top of Table Mountain, August, 1896, *J. K. Small*:—type, specimen in the herbarium of Columbia University.

## Proceedings of the Club

WEDNESDAY, FEBRUARY 27, 1901

This meeting was held at the Museum of the New York Botanical Garden. Dr. Allen presided. Twenty-five persons were present. Miss Delia W. Marble was chosen Secretary *pro tem.* Prof. A. D. Selby, Wooster, Ohio, was elected an active member.

The list of committees for 1901 was adopted as follows: Committee on Finance: J. I. Kane, C. F. Cox. Committee on Admissions: Cornelius Van Brunt, 319 E. 57th St., N. Y. City; Delia W. Marble, Bedford Park, N. Y.; John K. Small, Botanical Garden, Bronx Park. Committee on Library and Herbarium: Per Axel Rydberg, R. S. Williams, Anna M. Vail, Alexandrina Taylor. Committees on the Local Flora: Dr. N. L. Britton; Phanerogamia, Eugene F. Bicknell, H. H. Rusby, M.D., Fanny A. Mulford; Cryptogamia, Prof. L. M. Underwood, Marshall A. Howe, Ph.D., Mrs. Elizabeth G. Britton. Committee on Excursions, Dr. L. Schoeney, 1670 Lexington Avenue, New York City; George V. Nash, Eugene Smith, Marie L. Sanial, Miss L. K. Lawall. Committee on Program: N. L. Britton, Marshall A. Howe, L. M. Underwood.

The scientific program followed, introduced by Dr. Britton with a paper, "On some Senecios of the Eastern United States."

The critical study of this genus dates from 1893, when Dr. Rusby collected in the Green Mountains a peculiar plant, described but not published in the middle of the century by Oakes, and named by him *Senecio Robbinsii.* Dr. Rusby described this plant in the BULLETIN in 1893.

While working up the genus for the Illustrated Flora in 1895–6, Professor Britton found that *Senecio aureus* of Gray's Manual included six different things, and the following species were separated:

*Senecio obovatus, S. discoideus, S. Balsamitae, S. Smallii, S. compactus, S. Robbinsii,* besides *S. aureus* with two varieties.

Dr. Britton expressed the hope that field notes on this genus would be made during the coming season.

The second paper, also by Dr. Britton, was on *Eupatorium*, and illustrated the three Linnaean species, *E. purpureum*, *E. maculatum* and *E. trifoliatum*. The first two were collected at Copake Iron Works last summer on a field excursion of the Club.

*E. purpureum*, with thin almost glabrous leaves, with sharp teeth, grows in woodland and copses.

*E. maculatum* has leaves thick and rugose with prominent veins, broader and more ovate, and not as sharply serrate as the last; stem rough and spotted; grows in open meadows.

*E. trifoliatum* has been found in the south, as far north as Pennsylvania; it was named by Elliott, *E. ternatum*. The essential distinction of this species is the crenate leaves; the stem is smooth, the leaves narrower and inflorescence often larger than in *E. purpureum*.

Dr. MacDougal exhibited an experiment on the force exerted in the swelling of seeds; a strong iron pipe was filled with peas and water, and a test-tube inserted in the top. In 24 hours from the time the peas were put in a pressure was registered of eight atmospheres, or 120 pounds to the square inch, the highest pressure hitherto recorded by this means. Professor Underwood called attention to the action of fleshy fungi in lifting heavy paving stones in their growth.

Dr. MacDougal also discussed malformations in *Arisaema*. He called attention to the fact that early specimens may be infested with a fungus growth which causes the hood to stand erect.

It was voted that future meetings of the Club at the Garden be held at 3:30 instead of 4 o'clock.

DELIA W. MARBLE,
*Secretary pro tem.*

TUESDAY, MARCH 12, 1901

The meeting was held at the Museum of the Botanical Garden and was called to order at 4 P. M., with Dr. Allen in the chair. Dr. D. T. MacDougal was appointed secretary pro tem. Thirty persons were present.

The scientific program was presented as follows:

Dr. Marshall A. Howe gave a paper on "The Algal Genera *Acicularia* and *Acetabulum*," which is printed in full in the present issue of the BULLETIN.

The second paper, by Mrs. E. G. Britton and Miss Alexandrina Taylor, was on the life-history of *Schizaea pusilla*, *Lygodium palmatum* and *Vittaria lineata*.

Living and pressed specimens were shown of all three; also microscopic preparations and drawings illustrating the gametophyte from the spore to the sporophyte in the various stages of development.

For *Schizaea pusilla* the exhibit of the life-history was very complete, and the descriptions and plates have already been published in the BULLETIN for January.

Dr. C. F. Millspaugh, of the Field Columbian Museum, Chicago, spoke briefly on the results of a recent trip to the West Indies for the purpose of studying the economic fruits of the tropics.

D. T. MACDOUGAL,
*Secretary pro tem.*

## Index to recent Literature relating to American Botany

**Ashe, W. W.** Some East American Species of *Crataegus*. Jour. Elisha Mitchell Sci. Soc. **17**: 4–17. 20 D. 1900.
Twenty-one new species ranging from Illinois and New York to North Carolina.

**Bicknell, E. P.** A new Horse Gentian (*Triosteum*) common in the Eastern United States. Torreya, **1**: 25–28. 25 Mr. 1901.
*Triosteum aurantiacum* Bicknell.

**Blodgett, F. H.** The Erythroniums. Jour. N. Y. Bot. Garden, **2**: 37–39. 1901.

**Blodgett, F. H.** The *Lygodium* at Home. Torreya, **1**: 19, 20. 23 F. 1901.

**Blodgett, F. H.** Transpiration of rust-infested *Rubus*. Torreya, **1**: 34, 35. 25 Mr. 1901.

**Britton, E. G.** The rare Mosses of Bashbish Falls. Torreya, **1**: 9. 29 Ja. 1901.

**Britton, N. L.** A new *Senecio* from Pennsylvania. Torreya, **1**: 21. 23 F. 1901.
*Senecio Crawfordii* Britton.

**Britton, N. L.** Notes on *Rudbeckia hirta*. Torreya, **1**: 1, 2. 29 Ja. 1901.

**Britton, N. L.** The Morong Herbarium. Jour. N. Y. Bot. Garden, **2**: 35–37. 1901.

**Britton, N. L.** Weeping American Aspens. Jour. N. Y. Bot. Garden, **2**: 12, 13. *f. 1*. 1901.

**Burgess, E. S.** Fairylore of Flowers. Jour. N. Y. Bot. Garden, **1**: 161–168. 1900.

**Burglehaus, F. H.** Note on the involucral Leaves of *Syndesmon*. Ohio Nat. **1**: 72. Mr. 1901.

**Carss, E.** The Value of Forestry in a Course of Nature Study. Torreya, **1**: 13–16. 23 F. 1901.

**Chesnut, V. K. & Wilcox, E. V.** The Stock-poisoning Plants of Montana. Bull. U. S. Dept. Agric. (Div. Botany), **26**: 1–150. *pl. 1–36*. 1901.

**Cockerell, T. D. A.** Flower and Insect Records from New Mexico. Entomol. News, 1901: 38–43. F. 1901.

**Cole, E. J.** Grand Rapids Flora. A Catalogue of the Flowering Plants and Ferns growing without Cultivation in the Vicinity of Grand Rapids, Michigan. 1–170. 8vo. Grand Rapids, 1901. Map.

**Cook, O. F.** Priority of Place and the Method of Types. Science, II. **13**: 712, 713. 3 My. 1901.

**Coulter, S.** A Catalogue of the Flowering Plants and of the Ferns and their Allies indigenous to Indiana. Rep. State Geologist of Indiana, **24**: 554–1074. 1901.

**Cowell, J. F.** The Buffalo Botanic Garden. Jour. N. Y. Bot. Garden, **2**: 24–26. 1901.

**Ferguson, M. C.** Notes on the Development of the Pollen Tube and Fertilization in some Species of Pines. Science, II. **13**: 668. 26 Ap. 1901.

**Fernald, M. L.** Some new Spermatophytes from Mexico and Central America. Proc. Amer. Acad. Sci. & Arts, **36**: 491–506. Ap. 1901.

New species in *Fimbristylis* (4), *Cologania*, *Platanus*, *Alcoceria* gen. nov. *Euphorbia* (5), *Pernettya*, *Arctostaphylos* (2), *Parathesis*, *Evolvulus*, *Ipomoea*, *Cordia*, *Salvia* (5), *Monarda*, *Physalis*, *Ruellia*, *Valeriana*, *Lobelia* (2), *Heterotoma* (2), *Brickellia*, *Xanthocephalum*, *Bigelowia*, and *Solidago*.

**Greene, E. L.** New Plants from Alberta. Ottawa Nat. **15**: 42. My. 1901.

New species in *Berberis* and *Stellaria*.

**Griffiths, D.** Thriving under Difficulties. Torreya, **1**: 30–32. 25 Mr. 1901.

**Griggs, R. F.** Additions to the Sandusky Flora. Ohio Nat. **1**: 97, 98. Ap. 1901.

**Harper, R. M.** Synonymy of *Burmannia* and *Gyrotheca*. Torreya, **1**: 33, 34. 25 Mr. 1901.

**Holm, T.** Allies of *Stellaria media* (L.) Cyrillo. Ottawa Nat. **15**: 37–41. *pl. 1, 2.* My. 1901.

**Jepson, W. L.** A Flora of Western Middle California. 1–625. Berkeley, 16 Ap. 1901.

A descriptive manual, with keys to families, genera, and species. Includes new species and varieties in various genera.

**Kellerman, W. A.** Minor Plant Notes, no. 3. Ohio Nat. **1**: 98–100. Ap. 1901.

**Kellerman, W. A.** Notes on the Flora of Sandusky. Ohio Nat. **1**: 82–85. *pl. 8.* Ap. 1901.

**Kjellman, F. R.** Om Floridé-slägtet *Galaxaura* dess organografi och systematik. Kongl. Sv. Vet.-Akad. Handl. **33**[1]: 1–107. *pl. 1–20.* 1900.

Includes numerous new species from Florida, the West Indies, Mexico, and South America.

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**Leiberg, J. B.** The Bitterroot Forest Reserve. Ann. Rep. U. S. Geol. Surv. **19**[5]: 253–282. *pl. 62–73.* 1899.

**Leiberg, J. B.** The Priest River Forest Reserve. Ann. Rep. U. S. Geol. Surv. **19**[5]: 217–252. *pl. 48–61.* 1899.

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**Lloyd, F. E.** Notes on the Genus *Lycopodium.* Torreya, **1**: 5, 6. 29 Ja. 1901.

**Ludi, R.** Beiträge zur Kenntniss der Chytridiaceen. Hedwigia, **40**: 1–44. *pl. 1, 2.* 21 F. 1901.

**MacDougal, D. T.** A new exhibition Microscope. Jour. N. Y. Bot. Garden, **1**: 139–141. 1900.

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**MacDougal, D. T.** Seedlings of *Arisaema.* Torreya, **1**: 2–5. 29 Ja. 1901.

**Masterman, E. E.** The Sprouting of Cocklebur Seeds. Ohio. Nat. **1**: 69, 70. Mr. 1901.

**Maxon, W. R.** A List of the Ferns and Fern Allies of North America north of Mexico, with principal Synonyms and Distribution. Proc. U. S. Nat. Mus. **23**: 619–651. 4 My. 1901.

Includes several new combinations of varieties and species.

**Meehan, T.** *Clarkia elegans.* Meehan's Monthly, **11**: 65, 66. *pl. 5.* My. 1901.

**Nash, G. V.** Native summer Flowers in Cultivation. Jour. N. Y. Bot. Garden, **1**: 121–128. 1900.

**Nash, G. V.** The Asters and Goldenrods and their Relatives under Cultivation. Jour. N. Y. Bot. Garden, **1**: 171–174. 1900.

**Penhallow, D. P.** Notes on the North American Species of *Dadoxylon.* Trans. Royal Soc. Canada II. **6**: 51–95. *f. 1–18.* 1900.

**Renauld, F.** Note sur un Limnobium de l'Amérique du Nord et ses

relations avec une forme des Pyrénées. Bull. l'Acad. internat. Géog. bot. III. **10**: 7, 8. Ja. 1901.

*Hypnum* (*Limnobium*) *Bestii* Ren. & Bryhn, new subspecies of *H. molle* Dicks.

**Richards, H. M.** A modified Form of Respiration Apparatus. Torreya, **1**: 28–30. 25 Mr. 1901. [Illust.]

**Richards, H. M.** A simple Dynamometer. Torreya, **1**: 8, 9. 29 Ja. 1901.

**Riley, W. A.** *Rosellinia ovalis* (Ell.) Sacc. Torreya, **1**: 22, 23. 23 F. 1901.

**Robinson, B. L.** Contributions from the Gray Herbarium of Harvard University, new series no. XX. I. Synopsis of the Genus *Melampodium*. II. Synopsis of the Genus *Nocca*. III. New Species and newly noted Synonymy among the Spermatophytes of Mexico and Central America. Proc. Amer. Acad. Arts & Sci. **36**: 455–488. Ap. 1901.

New species in *Melampodium*, *Nocca*, *Dioscorea*, *Calochortus*, *Mimosa* (3), *Russelia* (2), *Piqueria*, *Ageratum* (3), *Eupatorium* (15), *Brickellia* (5), and *Calea*.

**Rusby, H. H.** Poisonous Plants that grow in our Bodies and how to contend against them. Jour. N. Y. Bot. Garden, **2**: 17–24. 1901.

**Schaffner, J. H.** A List of Kansas Desmids. Ohio Nat. **1**: 100, 101. Ap. 1901.

**Schaffner, J. H.** Perennial Tumbleweeds. Ohio Nat. **1**: 67, 68. Mr. 1901.

**Schmidle, W.** Algen aus Brasilien. Hedwigia, **40**: 45–54. *pl. 3, 4.* 21 F. 1901.

New species in *Pleurotaeniopsis*, *Cosmarium*, *Staurastrum*, *Gloeotrichia* (2), and *Pilgeria* gen. nov.

**Scribner, F. L.** Some Arizona Grasses. Circ. U. S. Dept. Agric. (Div. Agrost.) **32**: 1–10. 22 Ap. 1901.

New combinations and species in *Trachypogon*, *Panicum*, *Aristida*, *Sporobolus*, *Bouteloua*, and *Leptochloa*.

**Selby, A. D.** A condensed Handbook of the Diseases of Cultivated Plants in Ohio. Bull. Ohio Agric. Exp. Sta. **121**: 1–69. *f. 1–54.* S. 1900.

**Shimek, B.** The Iowa Pteridophyta. Bull. Lab. Nat. Hist. State Univ. Iowa, **5**: 139–170. Ap. 1901.

**Small, J. K.** The summit Flora of King's Mountain and Crowder's Mountain, North Carolina. Torreya, **1**: 7, 8. 29 Ja. 1901.

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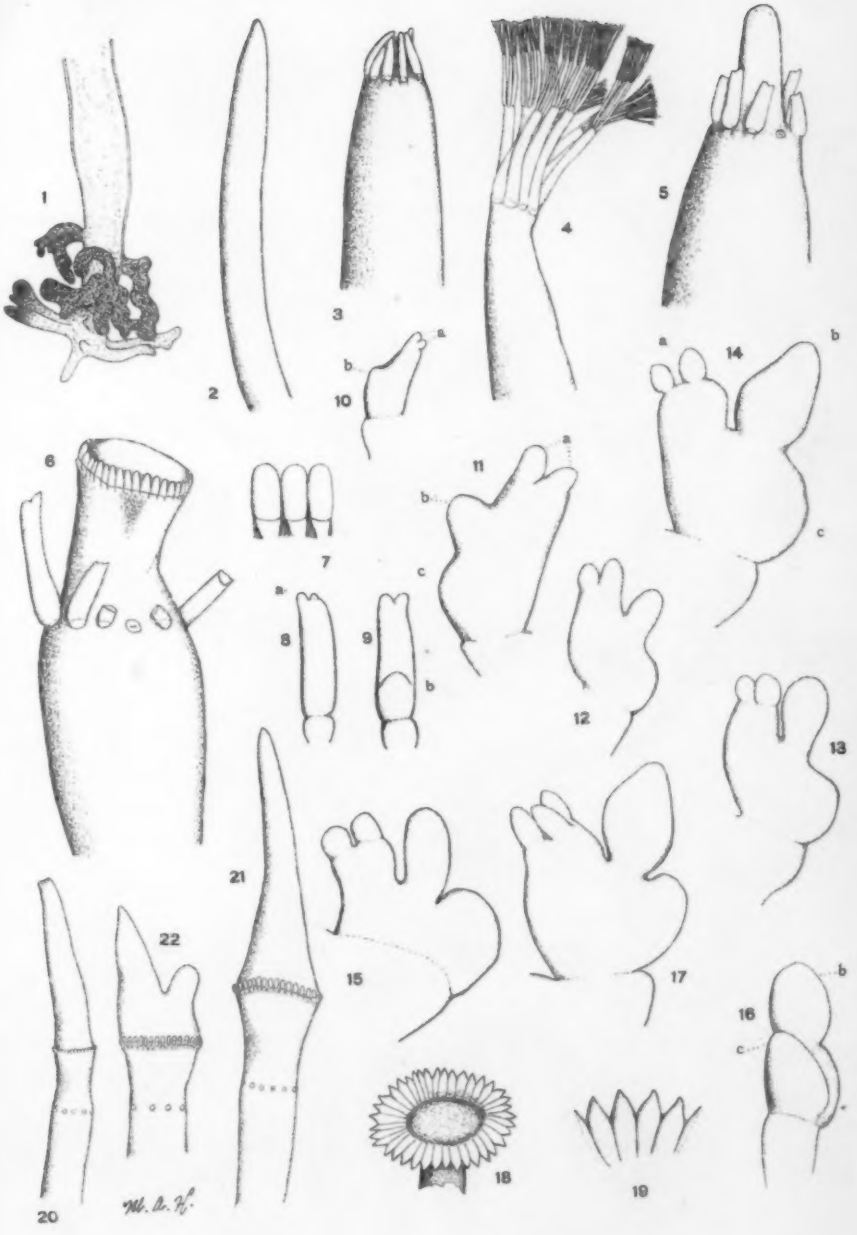
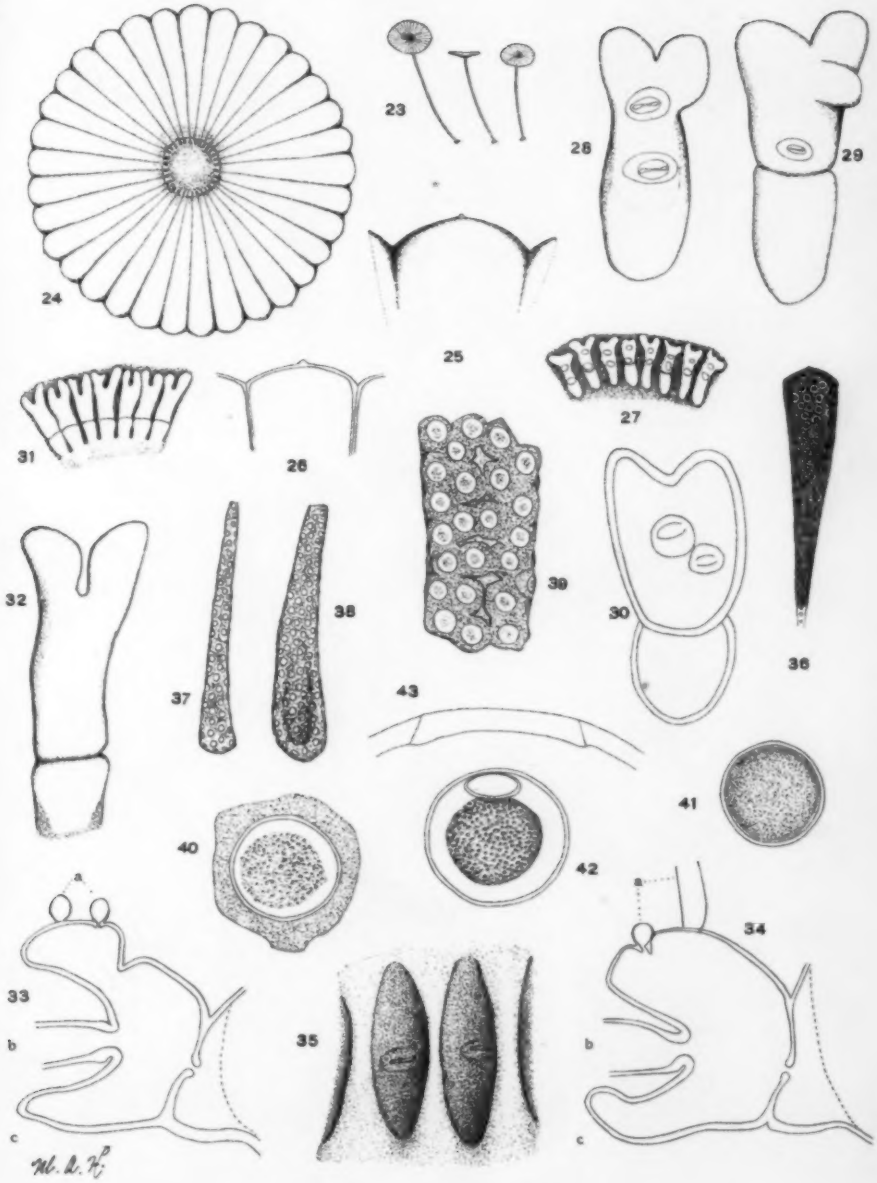
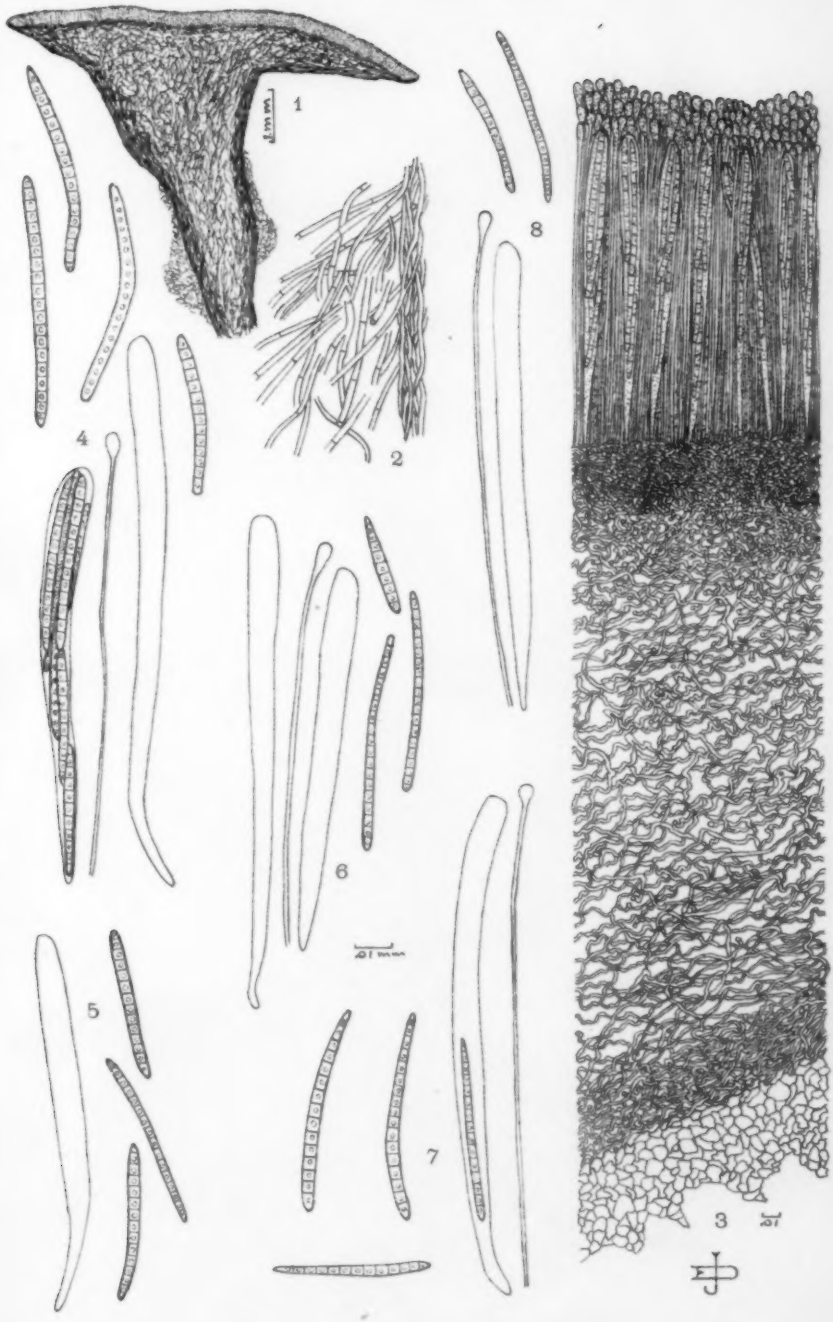



1-16, 18-22. ACICULARIA SCHENCKII (Möb.) Solms

17. ACETABULUM CRENULATUM (Lamx.) Kuntze




ACICULARIA SCHENCKII (Möb.) Solms




HOLWAYA GIGANTEA (Peck) Durand